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New Series Number 123

A SYMPOSIUM

ON THE

EFFECTS OF SOIL ELEMENTS ON FOOD

THIS VOLUME
TRACES SOME OF THE DISCOVERIES
OF SCIENCE
IN THE STUDY OF THE SOIL ELEMENTS
AS THEY AFFECT HUMANITY
THROUGH DIET

By T. J. BROOKS
Assistant Commissioner of Agriculture

PUBLISHED BY THE
FLORIDA STATE DEPARTMENT OF AGRICULTURE
NATHAN MAYO, Commissioner

TALLAHASSEE, FLORIDA

Florida, Dept. of Agriculture

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Notice

This Department cannot furnish analysis of soils or the foods you grow on the farm. The state chemist is authorized and equipped to analyze fertilizers, gasoline, drugs, stock feeds and canned goods.

This service is for the protection of the public from fraud in trade. If you want to know the mineral and vitamin content of the food you grow you will have to apply to a commercial analyst. A balanced fertilizer is the surest guarantee of balanced food.

Preface

This is not a treatise on dietetics, agronomy or soil analysis. Our subject is the relationship of these sciences to the health of mankind.

Agronomy and soil analysis have to do with the utilization of soils for production. Dietetics relate to the utilization of foods for the nourishment of the body. It takes all three to complete the relationship which they bear to human welfare. The importance of insuring a balanced diet by providing the required elements in the soils is just beginning to dawn on the public and to hasten interest concerning this subject is the purpose of the authors.

The source of physical being is in the soil ingredients no matter where one lives or his occupation. The ruins of ancient civilizations are solemn warnings of what will follow in this country if we neglect or abuse the soil. The erosion of millions of acres apparent on every hand point to the inevitable if we persist in distructive methods of cultivation, and indifference to the required elements which soils should contain.

There is another phase of this subject which is as important as volume production, and that is quality production. The same crop from the same seed and cultivation, but grown on different soils, will have different minerals and vitamins and therein lies the new science with its revelation of the connection of soil chemicals and human health.

ACKNOWLEDGEMENTS

Acknowledgements are given wherever quotations are made. A wide range of authorities have been consulted and liberal selections were made. Thanks are hereby tendered to one and all who have contributed to this symposium. May their tribe increase.

T. J. BROOKS

Contents

Introduction

Many acts in the human drama have marked the progress of mankind. Definite ideas have had their day and nothing is so powerful as an idea well-conceived and concerning human welfare. When its dawn is heralded there is always those who are ready to accept and those reluctant to be influenced by it.

The last act in a certain part of the drama is just being unfolded. The idea back of it is: *The Tremendous Influence That Soil Elements Have On Health.*

This is an age of exploration, not of unknown seas and savage lands but of unknown realms of the physical universe. It took more penetration to reveal the secrets of energy in nature than to discover the new continent. It required greater skill to explore the atom than to explore the Dark Continent. Science is a severe taskmaster and requires strict devotion. Inventions and discoveries have sprung from ideas that took possession of those who built modern civilization. Progress is carried on by those who do the ususual.

Reformers had more than selfish aims that caused them to enter the arena of social needs and proclaimed readjustment against apathy, ignorance, superstition and sordid desires. The reformation now going on in this country is a practical application of science to everyday living. It is neither political, military nor religious but purely scientific. Science probes mysteries but is nothing more or less than classified knowledge. It does not matter how that knowledge is obtained or by whom. He who is unlettered but

thinks may invent a complicated machine. A man does not have to be credited with a string of degrees to discover certain effects and by thinking trace effects back to causes.

This volume is a compilation of the results of experimenters seeking knowledge—and found it. Some were men of degrees and some were not. This symposium is sent forth on its mission by one who lays no claims to being a discoverer but believing in the discoveries others have made.

T. J. BROOKS

CHAPTER I

Soils

Without soils nothing could live on this planet except whatsoever could subsist on the foods from the sea and air. That part of the surface of the earth suitable to the growing of plants is soil. The elements contained in the various types of soil determine its suitability for the thousands of varieties of plant life. These elements combined with the physical conditions and the climate determine the zones of adaptation and productivity. Soils may be fertile and yet be too wet, too dry, too high, too cold, too warm to be favorable to growth and maturity of the myriads of vegetable growths. In turn these have much to do with the kind of animal life that is possible in the different parts of the earth. There must also be a certain equilibrium or balance of the soil constituents in order to supply the needs of plants that require varying amounts of mineral elements and in available form for the roots of the plants to take them up into the plant and its fruit. All this is true whether or not the plant is in any way beneficial or detrimental to man or other creature.

The mastery of soils in production and conservation determine the success or failure in agriculture. The commercial prosperity of agriculture is largely a question of the expertness in farm management and the marketing of the farm's output. Under modern civilization people in the remotest parts of the earth exchange with each other the products of their respective climes. This prevents the suffering that once occurred when a drouth, flood or other calamity overtook the people in one part of the world. Modern commerce and means of communication bring the ends of the earth to close proximity.

Agriculture is no longer a haphazard vocation, subject to the whims of stupidity or of accidents. It has its science the same as other vocations. It brings into service chemistry, agronomy, conservation, farm management and marketing.

The teeming millions of the earth must be fed from the bounties of the soil if they are to exist. It behooves each generation to leave the soil as fertile as it found it. For thousands of years this was not done and migrations were imperative. Now that the whole earth has been settled this running from the ruins we have wrought is impossible. We can use science in soil management or suffer the consequences. Scientific farmers will be the successful farmers of the future. He who knows best how to fertilize, conserve, cultivate and choose the crops best adapted to the soil and climate will succeed where others fail.

Another feature of agriculture is the planning and raising of crops that furnish in proper form the nutritive elements necessary for the proper feeding of the human body. Mere food is not sufficient. *The elements in food are the important thing.* All these must come from the soil through plants direct to man, or through plants to animals and then to man—and from the waters.

Scientific agriculture is the only hope for man's continued support, comfort and enjoyment of the glories of civilization.

CHAPTER II

Physical Requirements

The human body is made up of elements which it appropriates from Food, Drink, and Air. Whatever nourishment is required must be supplied from these sources. Unless they are to be had in the right quantities and proportion the physical organism is not properly nourished.

During all the aeons of time since man has inhabited this planet he has been unawares that the elements in the soil determined his physical welfare. Quantity of yield has been the sole basis of judging the value of soil. The quality of the product was never appreciated. When wild animals, birds and fish constituted the animal food, and a plot of ground was cultivated with sticks to grow a few vegetables and the wild fruits which grew and berries and nuts which were gathered, these constituted his diet. All of these were seldom present at once.

Modern civilization has changed the whole problem of making a living. By refering to the tables of requirements for the human body it will be seen that diet is indeed a complicated problem. It also shows that there is a direct connection between food elements and health. These elements are determined almost wholely by the soil from which food comes either directly through plants and their fruits or through the animals which are used for food. Animals must secure them from plants and their fruits.

As will be seen by perusal of this volume that a coterie of scientists and experimenters have risen to proclaim the importance and the benefits of understanding the processes of nourishment in all animal life and the effects of different diets on the different species—including man.

It has been discovered that very few soils contain all the ingredients needed to furnish a balanced ration to the denizens of the earth. It is up to man to devise methods that will insure balanced foods, with all the good results sure to follow.

CHAPTER III

Soil and Health

It has only recently been discovered that human health is closely related to the plant-food elements in the soils from which food is obtained.

Fact 1. It has been ascertained that the human body should contain different mineral elements in varying proportion, and various vitamins. These are derived from food and drink;

Fact 2. Plants get their food from the soil, water and air, and can get only that which they contain.

Fact 3. Plants will grow from soils lacking some of these elements and from soils that contain elements which the plant does not need.

Fact 4. Some Plants draw from the soil unneeded elements to far greater extent than others. Grains do not load us with the unnecessary elements but may lack some of them; many fruits and vegetables do; such as sugarcane, cabbage, potatoes, melons, etc.—also tobbaco.

Fact 5. Human beings can live on a diet that is lacking some of the elements needed and can live in spite of taking into the system things not necessary and even deleterious. No one needs nicotine, morphine, caffeine or pepper in his system as an accumulated residue. Nevertheless people live with all these in their system, due to habit in their use. We need lime, calcium, iodine, magnesium, etc., but lack of these in the food does not readily starve the individual but renders him less vigorous.

Fact 6. A balanced ration for human beings is dependent on a balanced ration for plants in the soil. Long life is de-

pendent on health, health on food, food on soil. Even meat diet comes from land animals which get their food from plants and water animals which get their food from creatures they find in fresh or salt waters.

CHAPTER IV

Soil Fertility and Human Nutrition

FERTILIZERS IN THE POSTWAR NATIONAL ECONOMY

It is recognized that there are soil deficiencies and occasionally toxic elements, notably selenium, in the soil which, through the medium of food and feed crops, have important effects on the nutrition and health of man and animals. It is also clear that these effects are sometimes operative under conditions where the soil fertility is such as to result in excellent yields of crops. More frequently, however, the nutritional effects are associated with low yields of crops and a generally low level of nutrition. Nevertheless, in terms of the soil's ability to meet nutrition and health needs, yields per acre may be, in certain situations, a poor measure of its capacity to supply all of these needs. This is the case when the nutritional deficiency is associated with the lack of a minor element, such as cobalt or iodine, which is essential in animal nutrition but apparently is not essential for the growth of higher plants. In addition to the known essential or harmful mineral constituents, there may well be undiscovered factors, probably influenced by the nature of the soil on which the crops are grown, which may have important significance. In general, however, crops produced by recognized good soil fertility practices, including the use of lime and fertilizers, usually have good nutritive properties.

It seems apparent that mineral supply in soils has much less influence on certain vitamins in plants than have variety and climate. It has been found, for example, that tomatoes grown in soils or in sand culture at various locations throughout the country varied significantly in ascorbic acid content. However, at any one location there was

little correlation of ascorbic acid with the supply of either macro- or micro-nutrients, even though the supply of these nutrients affected growth and fruitfulness of the plants markedly. One must not generalize, however, from these results that the soil has no influence on vitamins or other organic nutrients in food crops. It has been shown, for example, that boron supply influences the thiamin content of turnip greens.

It is clear that good nutrition in man is dependent, to a large degree, upon the production of animal products. This involves problems of quality of feeds. Here the relationship to soil is more direct and clearly defined than is true in the case of human nutrition. It has been adequately demonstrated, for example, that the content of mineral elements in plants is markedly affected by the fertility of the soil. In addition there is evidence that a changed mineral status in the plant affects its nutritional quality.

In the United States certain nutritional disorders in animals have been associated with soil deficiencies. Most frequently the deficiency is calcium or phosphorus, but also one or more of the minor elements is often involved. Recently it has become evident that the use of an improper balance of plant nutrients may be responsible for an actual lowering of the nutritive value of a crop with respect to certain minerals needed in "traces" only. Intensive use of the major plant foods may call for a greater use of minor elements than has been the case heretofore.

One of the important contributions fertilizers can make to improved nutrition, particularly of animals, is to make possible the growth of legumes and other nutritious crops instead of crops of low nutritive value. Without lime and fertilizer many soils will only produce timothy or less nutritious pasture or hay crops. Liming and fertilization would certainly improve the quality of timothy but it would also make possible the production of alfalfa instead of tim-

othy. It is such a change that would be a great forward step in the improved nutrition of livestock and indirectly of man.

It is clear that until more facts are gathered through research and their significance properly assessed, it is rather hazardous to speculate regarding the extent of the influence of soil fertility on human nutrition. The public interest in this general problem is increasing and indicates that the present need for adequate research to clarify the questions involved will be supported. A start has already been made. Five years ago, the U. S. Department of Agriculture established a Plant, Soil and Nutrition Laboratory to investigate the interrelationships involved. Such research requires painstaking efforts of highly trained scientists, and it cannot be expected that we will arrive at answers overnight; but we can look forward hopefully to a time when we will have a correct appraisal of the place of soil fertility and fertilizers in human nutrition.*

* The National Planning Association's Joint Committee on National Nutrition Policy will release shortly a statement of its recommendations for a nutrition program for the United States.

CHAPTER V

Health from the Ground Up

REX BEACH

Condensed from Hearst's International-Cosmopolitan

Do you know that most of us suffer from dangerous diet deficiencies which cannot be remedied until the depleted soils from which our foods come are brought into proper mineral balance? No man today can eat enough fruits and vegetables to supply his system with the mineral salts he requires for perfect health, because his stomach isn't big enough to hold them!

One carrot may look and taste like another and yet lack the particular mineral element carrots are supposed to contain. Vegetation grown in one part of the country may assay 1100 parts, per billion, of iodine, as against 20 in that grown elsewhere.

Any considerable lack of essential mineral elements, and we sicken, suffer, shorten our lives. And the alarming fact is that our fruits, vegetables, grains and meats are now being raised on millions of acres of land that no longer contains enough of these minerals.

The first man to demonstrate this was Dr. Charles Northen, an Alabama physician who had specialized in nutritional disorders. He became convinced that we must make soil building the basis of food building if we are to use foods intelligently in the treatment of disease.

"We know that vitamins are indispensable to nutrition," says Dr. Northen, "but it is not commonly realized that vitamins control the body's appropriation of minerals, and in the absence of minerals they have no function. Lacking

vitamins, the system can make some use of minerals, but lacking minerals, vitamins are useless! We have been systematically robbing soils of the very substances necessary to growth and resistance to disease. Up to the time I began experimenting, almost nothing had been done to make good the theft."

Dr. Northen retired from medical practice to devote himself to this subject. By putting back into soils the stuff that foods are made of, he raised better seed potatoes in Maine, better grapes in California, better oranges in Florida, and better field crops in other states—better not only in improved food value but also in increased quality and quantity. He doubled and redoubled the natural mineral content of fruits and vegetables. He improved the quality of milk by increasing the iron and iodine in it. He caused hens to lay eggs richer in the vital elements.

At least 16 mineral elements are indispensable for normal nutrition. Of these, calcium, phosphorus and iron are perhaps the most important. Calcium affects the cell formation and regulates nerve action. It coordinates the other mineral elements and corrects disturbances made by them. Among the actual diseases that may result from calcium deficiency are rickets, bony deformities, bad teeth and nervous disorders. Phosphorus is also exceedingly important. Dr. McCollum of Johns Hopkins says that when there are enough phosphates in the blood there can be no dental decay! Iron is an essential constituent of the oxygen-carrying pigment of the blood; but iron cannot be assimilated unless some copper is contained in the diet. And if iodine is not present, goiter afflicts us.

So each mineral element plays a definite role. The human system cannot appropriate those elements to the best advantage in any but the food form. So we must rebuild our soils: put back the minerals we have taken out. It isn't difficult or expensive. By re-establishing a proper soil bal-

ance Dr. Northen has shown he could grow crops that contained enough desired minerals.

I met him because I was harassed by soil problems on my Florida farm which had baffled the best experts. "A healthy plant," he told me, "grown in soil properly balanced, can and will resist most insect pests. You have germs in your system but you're strong enough to throw them off. Similarly, a really healthy plant will take care of itself against insects and blights—and will also give the human system what it requires."

When Dr. Northen restored the mineral balance to part of the soil in an orange grove infested with scale, the trees in that part became clean while the rest remained diseased. By the same means he had grown healthy rosebushes between rows that were riddled by insects. He had grown tomato and cucumber plants, both healthy and diseased, where the vines intertwined. The bugs ate the diseased plants and refused to touch the healthy ones! He showed me analyses of citrus fruit, the chemistry and the food value of which accurately reflected the soil treatment the trees had received.

I took his advice and fed minerals into land where I was growing a large acreage of celery. When the plants from this soil were mature I had them analyzed, along with celery from other parts of the state. My celery had more than twice the mineral content of the best grown elsewhere; and it kept much better, proving that the cell structure was sounder.

In 1927, W. W. Kincaid, a "gentleman farmer" of Niagara Falls, heard an address by Dr. Northen and was so impressed that he began extensive experiments. He has succeeded in adding both iodine and iron to soil so liberally that one glass of milk from his cows contains all of the minerals that an adult requires for a day.

"It is neither a complicated nor an expensive undertaking

to restore our soils to balance," says Dr. Northen. "Any competent soil chemist can tell you how to proceed. First determine by analysis the precise chemistry of any given soil, then correct the deficiencies by putting down the missing elements. The same care should be used as in prescribing for a sick patient, for proportions are of vital importance.

"A nutrition authority recently said, 'One sure way to end the American people's susceptibility to infection is to supply through food a balanced ration of iron, copper and other metals. An organism supplied with a diet adequate to, or preferably in excess of, all mineral requirements may so utilize these elements as to produce immunity from infection quite beyond anything we are at present able to produce artificially. You can't make up the deficiency by using patent medicine.'

"Happily, we're on our way to better health by returning to the soil the things we have stolen from it. The public can hasten the change by demanding quality in its food, insisting that health departments establish scientific standards of nutritional value. The growers will quickly respond. They can put back those minerals almost overnight.

"It is simpler to cure sick soils than to cure sick people. Which shall we choose?"

The original article was reprinted as a government bulletin, Senate Document No. 264, 74th Congress, Second Session.

CHAPTER VI

Experiment Station Research on the Vitamin Content and the Preservation of Foods

By GEORGIAN ADAMS, home economist, and SYBIL L. SMITH, principal experiment station administrator, Office of Experiment Stations, Agricultural Research Administration

Miscellaneous Publication No. 536, Washington, D. C.
March, 1944

INTRODUCTION

The previous custom of reviewing the results of research at the State agricultural experiment stations of particular interest to all aspects of home life has been suspended in this report in order to present a rather detailed review of the greatly expanded program of research on the nutritive value of foods as affected by various factors.

The new significance attached to food as an implement of war as well as peace has served to stress the fact that nutritional quality must be considered along with yield, appearance, and other factors in evaluating the importance of a food crop and its priority in a food production program. Furthermore, it is realized as never before that every effort should be made to prevent to the greatest possible extent losses in the nutritive value of foods during all the manipulative processes between production and final consumption. At a time when the food supplies for the armed forces, lend-lease shipments, and rehabilitation work are being allocated on the basis of their nutritive value, when nutrition programs for industrial workers are being established, and when throughout the country Victory Gardens are pro-

ducing a variety of crops for home consumption, the conservation of nutritive values of foods assumes equal importance with the production of foods of the highest possible inherent nutritive value.

Organization early in 1942, within the framework of the State agricultural experiment stations and the Department, of a National Cooperative Project on the Conservation of the Nutritive Value of Foods served as an impetus to a decided expansion of research in this field. A greater unification of methodology has been effected through technical committees with regional representation; the organization of the State groups under the leadership of an experiment station director in each region as regional coordinator is affording an opportunity for an exchange of ideas in the assembling of material on a regional basis; and an arrangement for issuing preliminary progress notes by the individual station makes it possible to obviate long delays in releasing data. At the time of writing, July 1943, no less than 43 stations and the Bureau of Human Nutrition and Home Economics are participating in this program. Included in the present report are some of the preliminary findings in projects set up as a part of the National Cooperative Project, although the greater part antedates the organization of the work in this field on a cooperative basis. The entire period reviewed extends from 1941 to as late as July 1943. Summaries of earlier studies are to be found in previous reports of experiment station research, the last two of which cover the periods for 1939-40 (137) [1] and 1940-41 (138).

Factors Affecting Vitamin Values of Foods

With recognition of the fact that the dietary vitamin intake is governed not only by the foods included in the diet but also by variations within individual foods, many investigations have been carried out to determine the source and the magnitude of the variations. The studies

[1] Numbers in parentheses refer to Literature cited.

indicate that there are several stages in which the vitamin content of a food is subject to variation. The first of these is during growth, with the result that a crop as harvested shows certain natural variations in vitamin content. After harvest there are often changes during storage. If the food is processed, as in milling or in preservation by freezing, canning, or dehydration, its vitamin content is further changed, and in the cooking of a food, whether in the fresh or any of its preserved states, there is opportunity for still further change in vitamin content. In the pages that follow an account is given of the studies concerned with these numerous influences.

Natural Variations

Natural variations in the vitamin content of a food as harvested were shown to result from the effects of various factors in operation as the crop was growing. The factors operating included climate and soil, variety, degree of maturity, and selective concentration in different parts of the plant. In foods of animal origin, the vitamin content was influenced by the feed of the animal and the ability of different tissues to store the vitamin.

Effect of climate and soil.—Large variations in ascorbic acid content reported within varieties of strawberries led Burkhart and Lineberry (21) to a study of the conditions affecting the vitamin C content. An improved method of extracting the ascorbic acid was employed. This involved emulsification of the sample for 1 minute in a mechanical blender with a metaphosphoric acid mixture. The determination was completed by titrating the centrifuged extract immediately with an electrometric titrimeter, according to the method of Kirk and Tressler (73). In checking possible causes of such variation, using North Carolina berries of known history, it was found that the ascorbic acid content of sun-ripened berries was greater than that of berries ripened in the shade, and that similarly sampled

berries from different fields varied appreciably in ascorbic acid content.

This difference between fields, associated with the effect of soil variation, was observed in Klondike strawberries from six fields, two experimental and four commercial, all receiving the same fertilizer treatment. The ascorbic acid in the berries by fields ranged from 36 to 52 milligrams per 100 grams although close agreement was found between duplicate quarts sampled under the same conditions as to location, time, degree of maturity, exposure to sunshine, and size of fruit. This range showed that different environments markedly affected the ascorbic acid content. From these results it was apparent, in the case of strawberries at least, that any comparison of the ascorbic acid content of different varieties, or any study of the effect of different treatments on ascorbic acid in a single variety, must involve considerable care to eliminate other sources of variation.

Montana-grown strawberries analyzed for ascorbic acid by Mayfield and Richardson (94) showed the same wide variations within varieties that were found in the North Carolina berries. Again, the variations appeared to be associated with differences in environmental conditions existing within a given field, on the one hand, and between seasons, on the other hand. Thus, berries of the Dunlap variety, always obtained from the same plot in Gallatin Valley, showed somewhat different ascorbic acid values for two seasons, and berries of the Gem variety, always obtained from the same plot in the Bitterroot Valley, showed evidence of decline in the values as the season progressed. Even at a given harvest there was a wide range in the values obtained for different lots of both the Dunlap and the Gem varieties. The values obtained are given in table 1.

Table 1.—Ascorbic acid values of Montana-grown Dunlap and Gem strawberries tested when fresh

Variety	Season	Tests No.	Ascorbic acid per 100 grams Average Mg.	Range Mg.
Dunlap	1940	10	79	65-89
Dunlap	1941	8	64	52-86
Gem Everbearing	1941, first crop[1]	8	80	69-89
Gem Everbearing	1941, first crop[2]	16	67	56-91
Gem Everbearing	1941, second crop[3]	11	61	49-77

[1]Picked July 1, at height of first bearing period.
[2]Picked July 29, at end of first bearing period.
[3]Picked August 26, at height of second bearing period.

The influence of locality and season on ascorbic acid content was apparent in the case of tomatoes of four varieties grown in 1938 and 1939 in four widely separated localities in Maine. The data obtained in this study by Murphy (108) showed that varietal differences were similar in the 2 years, with Penn State Earliana having the lowest ascorbic acid value and Bestal the second lowest in all four localities, and with Comet highest at Orono and Kennebunk and Best of All highest at Aroostook and Highmoor. In 1938 the majority of samples from Orono, Highmoor, and Kennebunk were higher in ascorbic acid content, by more than 6 milligrams per 100 grams, than those from Aroostook. The favorable effect of a given location as observed in the first year did not persist over the second year, however, for in 1939 tomatoes grown at Aroostook, while again lower in ascorbic acid than those grown at Orono, were, on the other hand, higher than those grown at Highmoor and Kennebunk. An analogous experiment in which four varieties of cabbage were used for the test crop confirmed the evidence obtained with tomatoes.

These findings indicated that environmental agencies influenced the synthesis of ascorbic acid in tomatoes and cabbages and that geographic situation was not a contributing factor except insofar as environmental conditions were characteristic of that situation. An analysis of available weather data suggested that sunlight, rainfall, and probably temperature might have been causal agents in the variations in ascorbic acid content. As the tissue matured there

was a definite rise in ascorbic acid concentration in the tomato and a decline in the cabbage. These phenomena were related to geographical situation to the extent that maturity rate was hastened or delayed by the climatic condition prevailing throughout the growing season.

In tests at the South Dakota station to determine the effect of cultural practices on the yield and quality of garden vegetables, McCrory and Snyder[2] grew the vegetables under lath shade and in the open. Three fertilizer treatments were used. Although the fertilizer influenced the yield—plots treated with Vigoro yielded highest, followed by those treated with manure, superphosphate, and the check plots—it caused no consistent variations in the vitamin content of the crops. In this particular season, which was cold and wet, the yields were consistently higher in the open than under shade. As for the vitamins, carotene was a little higher under shade, while ascorbic acid was considerably lower.

The effect of environment on the content of ascorbic acid was also observed in rhubarb grown at the Washington station. In this case, two varieties were grown over two seasons, both in the hothouse and in the field, and stalks harvested at prime maturity were analyzed. The analyses of each lot were made on composite samples of center sections from several stalks. A summary of the data from these determinations, made by Todhunter (144), showed the field-grown rhubarb to be consistently richer in ascorbic acid than the corresponding lots grown in the hothouse. The values obtained are reported by range in table 2.

Table 2.—Ascorbic acid in hothouse- and field-grown rhubarb

Variety	Ascorbic acid per 100 grams	
	Hothouse-grown	Field-grown
Fresh mature rhubarb:	Mg.	Mg.
Victoria	3 .5-5.8	6. 8- 8.0
Wine	5 .8-6.7	6 .5-16.7

[2]McCrory, S. A., and Snyder, L. C. Progress Report on Research Project 118. Improving Vegetable Yields and Quality by Cultural Practices. S. Dak. Agr. Expt. Sta. Hort. Pam. 26, [4] pp. 1943. [Processed.]

Effect of variety.—The preceding studies have indicated that environmental, soil, and climate factors all influence the nutritive value of a food crop. Although variations effected by environment may be of sufficient magnitude to mask varietal differences, this does not lessen the importance of varietal values in assessing the nutritive content of a food crop. A number of investigations of varietal differences in ascorbic acid content have been carried out. In these studies the several varieties of the crop were grown under comparable soil and climatic conditions so that the differences observed represented essentially those due to variety.

Varietal differences in Fairmore, Missionary, Massey, and Blakemore strawberries were studied by Burkhart and Lineberry (21) with careful attention to sampling in accordance with their observations as noted above. These varieties, grown at Willard, N. C., in the same field at the same fertility level and harvested when ripe, averaged, respectively, 66, 46, 42, and 33 milligrams of ascorbic acid per 100 grams. A similar study of other kinds of berries grown under comparable conditions in this North Carolina region, and sampled when ripe, was made by Lineberry and Burkhart (83). Varietal differences existed in regard to ascorbic acid values, as is evident from the average values tabulated below (table 3).

Table 3.—Varietal differences in ascorbic acid content of berries

Fruit and variety	Ascorbic acid per 100 grams	Fruit and variety	Ascorbic acid per 100 grams
Blueberries:	Mg.	Dewberries:	Mg.
Cabot	18.6	Young	32.5
Rancocas	18.4	Lucretia	27.0
Scammell	16.5	Boysen	25.9
Concord	16.0	Raspberries:	
Blackberries:		Dixie	32.5
Early Wonder	23.5	Latham	23.5
Brainard	12.9	Newburgh	20.5

The ascorbic acid content of seven varieties of muscadine grapes was investigated by Bell et al. (8). All varieties were grown in North Carolina in 1937, 1938 and 1939 on the same type of soil and with the same fertilizer treatment.

The fruits analyzed were firm and ripe and of characteristic size for each variety. The ascorbic acid content, as determined by the method of Mack and Tressler (89), averaged 6.8 milligrams per 100 grams of the edible portion of ripe scuppernong grapes and from 4.1 to 5.5 milligrams per 100 grams of the Labama, Eden, Thomas, and James varieties. The Mish and Hopkins varieties contained negligible quantities, averaging 1.8 and less than 0.2 milligrams per 100 grams, respectively.

In the studies just discussed, ascorbic acid has been shown to vary characteristically with different varieties. This influence of variety has been reported also in recent studies on the vitamin A content of fruits. Determinations by Reynolds and Cooper as reported by the Arkansas station (3, p. 19), showed that peaches may be a good or a poor source of carotene (provitamin A), depending largely on the variety. Among the 17 varieties of Arkansas-grown peaches examined, the carotene content ranged from approximately 20 to 500 micrograms per 100 grams of peach, or the equivalent of 33 to 833 International Units. The average carotene content of Elberta peaches, the variety most widely grown in Arkansas, was 290 micrograms per 100 grams of peach. Chilow, Leona, Rochester, Halehaven, Elberta Cling, Anabel, Ideal, Fair Beauty, and Golden Jubilee varieties did not differ significantly in carotene content from Elbertas, ranging in the order named from 350 to 210 micrograms per 100 grams of fruit. Two varieties, Early Crawford and Wilma, were significantly richer in carotene than Elberta, and five varieties, Golden Elberta, Mikado, St. John, Belle, and Lola Queen, were comparatively low in carotene. Of these low-carotene varieties, the three latter were white-fleshed and could not be considered significant as sources of vitamin A, since their carotene contents were less than 24 micrograms per 100 grams.

According to Schroder et al. (132), the ascorbic acid content of peaches does not show the marked variation by va-

rieties that was observed by Reynolds and Cooper in carotene. In the eight varieties of peaches obtained from a restricted area near Raleigh, N. C., and with individual fruits selected for similarity of size and degree of ripeness, ascorbic acid varied only from 3.84 milligrams per 100 grams for the Augbert to 12.86 milligrams for the Hiley. The extreme difference between varieties was only 9.02 milligrams per 100 grams of fruit, whereas the average difference within varieties was 4.29 milligrams per 100 grams.

Six varieties of avocados grown at the subtropical station at Homestead, Fla., were analyzed by French and Abbott (60) for carotene and ascorbic acid. In this fruit also, vitamin differences by varieties were evident (table 4), although the order with regard to ascorbic acid level was not the same as that for carotene content. In the former case the earlier varieties were higher in vitamin C, but this factor did not consistently affect the carotene content.

Table 4.—Varietal differences in ascorbic acid and carotene contents of avocados

Variety	Ascorbic acid per 100 grams	Carotene per 100 grams
	Mg.	Mg.
Pollock	37	510
Trapp	31	140
Waldin	28	410
Lula	13	130
Booth "8"	10	240
Collinson	7	280

The ascorbic acid content of mangoes grown in Hawaii was found by Miller and Louis to vary greatly with the variety. Their data, as reported by the Hawaii station (65, p. 134), showed that of the samples tested, the common mango (Manini) had the highest value, or 114 milligrams per 100 grams of fruit, followed by the Wootten with 90 milligrams, Bishop with 33 milligrams, and the Haden and Pirie with 14 milligrams. The Pirie mangoes, although of superior flavor and texture, showed consistently low ascorbic acid values in samples collected from three locations in two seasons.

Among vegetables, an example of variation in vitamin

level associated with varietal differences was found in the data obtained by Murphy (107) on the ascorbic acid content of Maine-grown onions. These values are summarized in table 5. In one phase of the study the inner central part of mature onions, consisting of the younger smaller leaves, was analyzed separately from the outer part, made up of physiologically older tissue. In each of 10 varieties the ascorbic acid of the central part exceeded that of the periphery, and differences between varieties were caused principally by variations in this central part.

Table 5.—Ascorbic acid in different varieties of fresh raw onions grown at Orono, Maine

Variety	Ascorbic acid per 100 grams in— Mature and immature samples[1] Mg.	Mature samples[2] Mg.
Early Red Globe	40	....
Yellow Globe Danvers	36	....
Silverskin White Portugal	34	....
Brigham Yellow Globe	33	....
Early Yellow Globe	31	....
Southport Red Globe	30	22
Mountain Danvers	30	....
Southport Yellow Globe	27	18
Earliest White Queen	22	17
Riverside Sweet Spanish	21	17
Southport White Globe	21	16
White Sweet Spanish	20	14
Extra Early Yellow	20	13
Ebenezer	19	13
Yellow Bermuda	19	18
Crystal White Wax	17	15

[1]The values include data on immature and mature onions harvested at intervals from Aug. 1 to Sept. 23, 1938.

[2]Onions at least 1 inch in diameter.

Effect of maturity.—These results with onions suggest that stage of maturity may often be a factor influencing the vitamin content of a fruit or vegetable sample. Thus, in the study by Murphy, the small immature onions, harvested early in the season while still small and straight, were higher in ascorbic acid content than larger onions harvested later in the season. In the comparison of the younger smaller leaves, constituting the central part of the bulb, with the older outer leaves, the former were found

to contain from 0.14 to 0.73 milligram per gram, while the latter contained from 0.04 to 0.13 milligram.

Although onions apparently decreased in ascorbic acid content with increasing maturity, peppers were found by Lantz (82, 111) to increase markedly in ascorbic acid as the fruit matured. This increase in vitamin value as the peppers ripened was still more pronounced in the case of carotene, amounting in the variety Hungarian Paprika, for example, to as much as a fiftyfold increase in concentration between the immature green and the red ripe samples analyzed. These changes in vitamin concentration with increasing maturity are shown by the data taken from the study by Lantz and summarized in table 6. Here varietal differences in peppers were evident, although pungent varieties as a class apparently were not different from the sweet varieties. Maturity differences, however, were so much greater than varietal differences that any comparison of the vita-

Table 6.—Carotene and ascorbic acid content of peppers (sweet and pungent varieties) grown at the New Mexico Agricultural Experiment Station.

Variety	Color	Carotene per 100 grams			Ascorbic acid per 100 grams		
		Immature	Partly ripe	Ripe	Immature	Partly ripe	Ripe
		Mg.	Mg.	Mg.	Mg.	Mg.	Mg.
White Casaba	Yellow	0.09	....	....	....	....	....
	Green	....	0.20	....	....	....	....
	Red	....	....	4.17	....	....	....
Florida Paprika	Green	.63	....	....	99	....	....
	....	....	2.18	....	....	251	....
	Red	....	....	13.74	....	....	278
Long Red Paprika	Green	.55	....	....	115	....	....
	Green side	....	....	....	....	202	....
	Red side	....	....	....	....	261	....
	Red	....	....	9.50	....	....	560
Hungarian Paprika	Green	43	....	....	....	....	....
	Red	....	....	22.61	....	....	....
Jubilee of Honor	Yellow	.03	....	....	....	....	....
	Orange	.12	....	....	....	....	....
Bell	Green	.36	....	....	248	....	....
	Red	....	....	12.38	....	....	....
Chile No. 9	Green	.49	....	....	254	....	....
	....	....	....	....	....	308	....
	Red	....	....	11.93	....	....	326
Anaheim Chile	Green	.56	....	....	....	....	....
	....	....	3.14	....	....	....	....
	Red	....	....	11.40	....	....	....

min content of different varieties would seem to necessitate great care in the matter of sampling.

Carrots of six varieties grown in Colorado were found by Pyke and Charkey (124) to increase rapidly in vitamin A (carotene) value during the growing season. Harvested as baby carrots, these varieties, planted early in the season, averaged 74 micrograms of carotene per gram of sample (range by varieties, 70 to 85 micrograms); corresponding samples harvested as mature carrots of at least 2 inches crown diameter averaged 180 micrograms per gram (range, 146 to 255). In other trials the same varieties planted later in the season averaged 84 micrograms per gram (range, 65 to 102) when harvested as baby carrots and 215 micrograms (range, 161 to 282) when harvested as mature samples. These maturity differences in carotene content were much more pronounced than the varietal differences observed. In the case of ascorbic acid, varietal differences were slight, and from bunching size (¾ to 1 inch in diameter) onward the stage of maturity of the carrots did not seem to influence the ascorbic acid content of the tissue.

Increase in ascorbic acid content with increasing maturity was observed in strawberries by Burkhart and Lineberry (21) and in blueberries and blackberries by Lineberry and Burkhart (83). These fruits were grown in North Carolina. In Klondike strawberries the ascorbic acid content increased from 59 milligrams per 100 berries (244 grams) in the case of green berries to 280 milligrams per 100 berries (605 grams) in the ripe fruit. This represented a twofold increase in concentration—from 24 to 46 milligrams per 100 grams—and almost a fivefold increase in the amount of ascorbic acid elaborated as the berries grew and matured. Blueberries of the Scammell variety contained but 3.3 milligrams of ascorbic acid per 100 grams when green, as compared with 16.5 milligrams when ripe, and Brainerd blackberries increased from 11.6 to 12.9 milligrams of ascorbic acid per 100 grams as the berries progressed from the red to the ripe stage.

Cantaloups grown at the Arizona station were analyzed for ascorbic acid content by Smith, Burlinson, and Griffiths,[3] who employed the analytical method of Morell (99). As part of this study, the effect of stage of maturity on vitamin C in Arizona strain No. 45 was investigated. The results obtained showed that in this fruit also the ascorbic acid content increased as the fruit matured. Green melons of the first harvest averaged 29.5 milligrams of ascorbic acid per 100 grams of edible portion; this amount increased with successive harvests until at the time of the fourth harvest, when the cantaloups were fully ripened, the edible portion averaged 40.6 milligrams per 100 grams. In another group, melons received in an overripened, almost rotten, stage showed a sharp reduction in ascorbic acid to the point of containing only about one-half as much vitamin as did the mature edible melons.

Honeydew melons analyzed as part of this study showed the same tendency as did the cantaloups, namely, to increase in ascorbic acid as they matured but to decline as they passed the prime ripe stage. When picked green they averaged only 16.7 milligrams of ascorbic acid per 100 grams of edible portion (range, 14.2 to 20.7 milligrams) ; when picked "field ripe" but not full ripe and analyzed after shipping they contained 25.6 milligrams per 100 grams (20.8 to 27.6) ; but when picked fully ripe and then shipped the shipped samples averaged but 18.8 milligrams per 100 grams (range, 14.4 to 20.9).

The influence of the stage of maturity on the ascorbic acid content of peaches was investigated by Schroder et al. (132). In seven of the eight varieties grown in commercial orchards near Raleigh, N. C., peaches picked at the hard (green) stage were lowest in ascorbic acid. Successive samples picked through the various stages of ripeness classified as firm (hard ripe or shipping stage), ripe, and

[3] Smith, M. C., Burlinson, L. O., and Griffiths, A. E. Cantaloup—an excellent source of vitamin C. Ariz. Agr. Expt. Sta. Mimeographed Rpt. 53, 8 pp. 1943. [Processed.]

soft (overripe) showed a continuous increase in ascorbic acid concentration. This variation is indicated by the data in table 7.

Table 7.—Relation of ascorbic acid content to ripeness of peaches

Variety	Peaches	Average ascorbic acid content per 100 grams Hard	Firm	Ripe	Soft
	No.	Mg.	Mg.	Mg.	Mg.
Early Wheeler	28	4.05	5.35	7.36	8.28
Golden Jubilee	23	3.78	4.25	6.13	7.71
Elberta	22	4.39	4.45	5.25	....
Hiley	21	6.84	8.56	12.86	14.05
Mayflower	20	....	4.59	5.34	5.57
Early Rose	20	5.31	5.36	7.18	....
Carman	14	....	6.06	8.82	10.53
Augbert	8	5.36	4.55	3.84	....

Of the several fruits just considered, it was apparently characteristic for the vitamin content, ascorbic acid in particular, to increase with increasing maturity. This was not the case, however, with mangoes grown in Hawaii and analyzed by Miller and Louis (65). According to their analyses, green mangoes of the five varieties tested contained more ascorbic acid than the ripe ones.

Effect of part sampled.—As pointed out in the discussion of onions, the ascorbic acid content was not uniformly distributed throughout the bulb but was present in higher concentration in the inner than in the outer part. The red side of the partly ripe pepper, as analyzed by Lantz and reported by the New Mexico station (111), was found to be richer than the green side in ascorbic acid. These differences in vitamin content were apparently associated with the fact that not all parts of the food sample were developed to the same degree of maturity.

In other cases this lack of uniformity of vitamin concentration throughout the sample was associated with selective distribution of the vitamin in different structural parts of the grain, fruit, or vegetable. Thus, in the cereals, Kik (72) (Arkansas) found thiamine of rice to be concentrated in the outer bran layers and the germ; and Teply et al. (143) (Wisconsin) also found nicotinic acid, pantothenic acid, and pyridoxine to be concentrated in the bran and the germ of

wheat. In fruits the vitamin concentration was often higher in the outer than in the inner parts. For example, the concentration of ascorbic acid in scuppernong grape skins was about three times as high as in the edible portion, according to Bell et al. (8) ; and nicotinic acid concentration in apple skins analyzed by Teply et al. (142) was about twice that in the flesh. Outer parts of strawberries and peaches were richer than the center portions in ascorbic acid according to analyses by Burkhart and Lineberry (21) and Schroder et al. (132), respectively. Among vegetables, the parsnips used by Brown and Fenton (18) (New York (Cornell)) did not have the ascorbic acid uniformly distributed between tip and upper parts or between medulla and cortex; the buds of fresh broccoli analyzed by Barnes et al. (5) (New York State) were richer in ascorbic acid than were the stalks; and leaf blades of various greens were found by Sheets et al. (134) (Mississippi) to be richer than the petioles in carotene and ascorbic acid.

These examples of variable distribution of vitamins within a food are in many cases chiefly of interest to the analyst who is charged with the responsibility of selecting the analytical sample in such a way that it will be representative of the food as eaten. In other cases these variations are of importance in selecting and preparing foods with a view to obtaining maximum food value compatible with good culinary practice.

Effect of feeding practice.—The influence of the ration of the animal on the nutritive quality of food of animal origin is illustrated by the results obtained at the North Dakota station by Christensen, Knowles, and Severson (27), who investigated the effect of the ration on the nicotinic acid content of pork. They analyzed the livers, loins, and hams of pigs from different lots fed, for 113 to 138 days, the same basal feed mixture but supplemented in the different groups with 100, 300, or 500 milligrams of nicotinic acid per head daily. The nicotinic acid content of the tissues of these animals and of two control groups receiving no nico-

tinic acid supplement was compared with that of tissues from control pigs analyzed at the beginning of the experiment. The data, summarized in table 8, showed that the liver was much richer than the muscles in nicotinic acid, but that the amount stored in the liver bore no relation to the amount in the ration. In the loins and the hams, however, the nicotinic acid stored reflected the increase in the amounts of nicotinic acid fed. Neither the basal feed mixture alone nor this supplemented with alfalfa pasture increased the nicotinic acid in the loins and hams.

Table 8.—Influence of ration on the nicotinic acid content of pork.

Group	Nicotinic acid fed per head daily	Nicotinic acid per 100 grams: Liver, Fresh basis	Liver, Moisture-free basis	Loin, Fresh basis	Loin, Moisture-free basis	Ham, Fresh basis	Ham, Moisture-free basis
	Mg.	Mg.	Mg.	Mg.	Mg.	Mg.	Mg.
Check group[1]	None	15.7	55.2	4.3	17.8	6.0	25.8
Control groups:[2]							
Feed mixture alone	do	13.5	50.9	4.7	18.5	5.7	24.2
Feed mixture+alfalfa pasture	do	13.7	49.2	4.7	17.6	5.2	20.7
Test groups:[2]							
1. Feed mixture+nicotinic acid	100	15.1	53.9	7.4	28.3	7.4	30.6
2. Feed mixture+nicotinic acid	300	14.5	52.7	8.1	32.5	7.8	32.9
3. Feed mixture+nicotinic acid	500	14.8	54.8	8.9	36.3	8.8	36.9

[1] Analyzed at beginning of experiment.
[2] Analyzed at end of experiment.

A similar study, designed to show to what extent the thiamine content of pork is influenced by the thiamine intake of the pig, was carried out at the Pennsylvania station. In these tests, reported by Miller et al.,[4] pigs in three lots were fed for 118 days, during which time they all consumed essentially the same amount of the basal feed mixture, but received in their feed thiamine supplements amounting to 7, 18, and 29 milligrams per pig per day in the three lots, respectively. Analyses of various tissues of the pigs slaughtered at the end of the experiment showed that the thiamine

[4] Miller, R. C., Pence, J. W., Dutcher, R. A., and others. The influence of the Thiamine Intake of the Pig on the Thiamine Content of Pork. Pa. State Col. Natl. Coop. Proj., Conservation of Nutritive Value of Foods. Prog. Notes, 3 pp. [1943.] [Processed.]

tended to deposit in the muscle tissue, and that there was a positive relationship between the thiamine intake and the thiamine content of the pork muscle. Thus, increasing the thiamine intake from 7 to 18 milligrams per day resulted in an increase of approximately 100 percent in the thiamine content of the pork shoulder and loin (the thiamine content of the shoulders was from 20 to 30 percent lower than that of the loins). A further increase of intake to 29 milligrams per day resulted in a further increase of 15 to 20 percent in the content in pork muscle. In the case of the liver the same relationship existed but was not as striking as in the case of muscle tissue because of the relatively low thiamine content of pork liver. The values obtained are summarized in table 9.

Table 9.—The thiamine content of pork as influenced by the content of the feed

Item	Thiamine		
Thiamine in feed ....ug. per lb.........	5,761	3,447	1,315
Average daily thiamine intake........mg........	29	18	7
Average thiamine content of pork:......ug. per gm.........			
Shoulder:			
Fresh basis ....do........	17.3	15.1	7.9
Moisture-free basis ....do........	64.8	53.1	28.3
Center loin:			
Fresh basis ....do........	23.1	20.0	9.5
Moisture-free basis ....do........	83.5	72.8	32.8
Ham end of loin:			
Fresh basis ....do........	23.9	20.1	10.3
Moisture-free basis ....do........	88.8	72.0	36.6
Liver:			
Fresh basis ....do........	5.3	4.5	3.3
Moisture-free basis ....do........	17.5	14.5	10.8

Incidental to this study the riboflavin values of the pork were determined. The results indicated that the riboflavin was concentrated in the liver rather than in the muscle and that the riboflavin content of the various tissues bore no particular relationship to the riboflavin in the feed, at least at the levels fed (1,669-2,468 micrograms per pound of feed). The livers contained from 40.5 to 43.8 micrograms of riboflavin per gram of fresh tissue, and the shoulders and loins from 2.2 to 3.5 micrograms per gram (fresh basis).

CHAPTER VII

Soils and Food

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(Read at Meeting of The Egyptians, Feb. 17, 1944)
MEMPHIS, TENNESSEE

Food is a pleasant subject of conversation when it is plentiful, but a very serious subject when it is scarce. From the cradle to the grave, it is on our minds three or four times a day. Men work and labor for many wants, but their primary goal is enough food. We can do without clothes, shelter and other wants of civilization, but we must have food.

The Lord's Prayer expresses only one material desire—"Give us this day our daily bread." No doubt, other modern and ancient religions have a similar appeal to their divine power.

The use of ration books and regulations in this war have given our city folks a forcible education on the cost, supply and distribution of the things we eat. Thousands of our people, for the first time, have been growing Victory gardens. Here they have learned that it takes skill, labor and patience to produce food, and the experience has increased their respect for the farmer who tills the soil for a living.

We have all been concerned over the sudden and surprising shortage of many of the foods we like. It has been especially confusing because for ten years past, the problems arising from a surplus of food supplies have been hanging over us and disturbing our whole economic system.

The basic reasons for present food problems are important, but not commonly understood. For twenty-five years prior to the present war, food production did not

keep pace with population. For the four years just previous to the present war, the per capita food production was less than during the corresponding period prior to World War No. 1, and from 1930 to 1940 food production was the lowest of this century. Yet, during that time we accumulated enormous farm surpluses, and the real reason for this trouble was not overproduction but inability of consumers to buy.

There was, and is, an unbalance between agriculture and industry. The bulk of agriculture is carried on by millions of farmers. The bulk of industry is carried on by a few large corporations. A few large corporations exercise powerful control over industrial production and prices. When they have to meet a drop in consumer purchasing power, industry does not lower prices of their product, but curtails production, which reduces employment. This rigidity of prices still further lowers consumer purchasing power and aggravates the situation of the farmer.

Farmers usually make one crop a year and they cannot, like a factory does, shut down or reduce their production any Saturday night, or the first of the month. They have to mature the growing crop and accept market prices for their products. Whatever the farmer's individual views may be, he cannot escape the hard fact that the returns from his farm are directly affected by the income of the great mass of industrial workers who are the consumers.

During those years of reduced consumption, great surpluses of cotton, wheat, corn, hogs, cattle, and other crops accumulated, although production was really below normal. The market prices of many crops were lower than the cost of production, and it became necessary for the government to take some drastic action to prevent large sections of our agricultural territory from bankruptcy. Secretary of Agriculture Wallace advanced his sensible idea of a "normal granary," and Congress passed legislation to take over these surpluses through actual purchase and by commodity

loans, and also to control the future acreage of some crops. Uninformed and critical men did then, and do now, oppose those regulations, but the fact remains that farmers voted for and approved the restrictions placed upon themselves, and believe they have been benefited by them and so have the rest of the population.

There has been a lot of loose talk about the policy of "scarcity," and it comes, usually, from people who seem to have the philosophy that a farmer can, and should, produce plenty of cheap food and fiber for the other people, regardless of his costs, or labor, or returns. Following the practice of industry to meet "reduced consumer demands" by cutting production, producers of basic crops asked for government restrictions on their acreage, and gladly accepted them.

With a ten million bale surplus on hand and a very limited demand at low prices in sight, cotton farmers plowed up part of their planted cotton crop in 1933, reducing the probable crop four million bales, and yet definitely received more returns for the amount they harvested than they would have received had they finished and marketed the whole crop. The United States Supreme Court decided that the Bankhead Act, which authorized these regulations, was unconstitutional and, in consequence, in the year 1936 regulations were removed and we made a nineteen million bale crop instead of a thirteen million crop, as had been planned. That six million bales have been on our hands ever since and it is here even now. Its effect has depreciated the price of every bale of cotton grown since 1936, and has cost the government, as well as the cotton farmer, many, many times the value of the original six million bales.

There have been shed many crocodile tears about the government "killing the little pigs." The story is interesting and worth telling, as it has been misrepresented from the start. In January, 1933, the farm price of hogs was the lowest in fifty years, and less than three cents per pound.

The buying power of a farmer's return from one hundred pounds of live hogs was only 36.5 per cent of what it had been during the 1909-14 period, or what is known as the base parity price period. The value of hogs had been running over one billion dollars a year, and dropped to four hundred million dollars. Corn, which governs the price of pork, was selling for less than twenty cents per bushel, as compared with sixty-four cents during the parity price period. Beef cattle were selling for less than four cents, and sheep around two cents per pound. The two principal reasons for this price decline were the reduced employment and earnings in the United States, and the violent fall in the hog and lard exports. Exports dropped from an annual figure of two billion pounds to six hundred million, or from 24 per cent of the total production to 2 per cent. Payrolls and employment had dropped 60 per cent. The hogs, however, kept breeding and growing and had to be fed or allowed to starve.

With those prices, hog and corn farmers faced certain bankruptcy and, with no purchasing power to buy the products produce in the city, could only aggravate the depressed situation of industry. In an effort to relieve the distress which existed in all lines of agriculture, the new administration passed what is known as the Agricultural Adjustment Act, and the hog legislation is part of that act.

Under this program, there were purchased from farmers in forty-one states, six million four hundred thousand pigs at a cost of thirty million dollars. Every animal was processed by an authorized butchering plant. All edible products were turned over for relief distribution. Pigs which could not, on account of small size, be processed into dry salt pork, were rendered into grease and fertilizer tankage. In addition to the ninety-seven million pounds of dry salt pork, they obtained twenty-one million pounds of inedible grease, and ten million pounds of fertilizer.

While the pigs were killed, they were not destroyed. We

raise pigs for the purpose of killing them and not for their society, so these six million did not suffer any worse fate than all the other pigs in the world—and they were no more innocent. Had these pigs been allowed to grow and be sold on the market the following year, they would have not only consumed sixty million bushels of corn and other feed, but would have reduced and held down the price of all pork so that the gross income of the farmer would have been less with those hogs than without them—to say nothing of the labor and effort thrown away, as hogs have to be fed every day.

Inside of two years, by 1935, prices advanced from three cents to eight and one-half cents per pound, and farmers' purchasing power increased accordingly, to the benefit of industry, as well as themselves. Had the action not been taken, hog farmers could not have continued and the number of brood sows and fine breeding stock would have been so decreased that it would have taken several years to put us back into proper production. Consumers, naturally, want cheap food, but they can force the price down to a point where the producer cannot survive, and then there will be either a scarcity or no food at all.

Those agricultural surpluses were an economic headache, but when the war came along they were the greatest asset we had. Plenty of cotton, tobacco, wheat, corn, rice, cattle and hogs were on hand. From the higher prices received, the farmer was soon back on his feet financially, prepared to produce to the limit, and for the past two years he has made the largest crops ever grown.

We were struggling during that period with a price problem, not a surplus problem, and when employment increased, consumption rose and the so-called surpluses disappeared quickly. Besides the largest home consumption of food, the result of this stepped-up buying power caused by the increased employment and increase in wages for the past two years, we are feeding ten million soldiers who eat twice as

much as in civilian life, and are also sending unbelievable quantities of food to our Allies. These shipments are going to the Arctic Zones and to the Tropics, and the very best qualities of foods have to be used, and be perfectly preserved and packed.

Seventy per cent of the business of the world is the production, transportation and sale of food, so it deserves our attention and respect. We go to our corner grocery and are easily displeased to not find exactly what we want on the shelves. There is an extensive and important business between the farmer and the consumer, but let me give you a few figures of what the farmer must produce, gather and market in order to please you.

We all use milk, butter and cheese. Did you know there are twenty-seven million milk cows in the United States, one for every five people? They produce fifty-six thousand million quarts of milk per year, enough to give us each four hundred quarts. Don't forget cows have to be fed and milked two or three times a day, and that some farmer is attending to your family cow.

We all use citrus fruits. This year we will produce:

219,000	carloads of oranges.
123,000	carloads of grapefruit.
37,000	carloads of lemons
367,000	carloads—Total.

That means one thousand carloads are consumed every day and twenty trainloads of fifty cars each must leave California, Florida or Texas every day. A carload contains seventy thousand oranges, or one hundred twenty-one thousand lemons, so that we consume over forty million oranges every day and fifteen million lemons.

We don't seem to eat very much bread, but the wheat acreage in the United States is forty-nine million acres, over twice as large as our entire cotton acreage, and the

production equals about six bushels for each of us, or the equivalent of one and one-third barrels of flour.

The corn acreage is ninety-four million acres, over four times as large as our entire cotton acreage. The production amounts to three billion bushels, which equals over twenty bushels for each one of us. We don't have to eat that much directly, because a large amount of corn goes to feeding cattle and hogs.

We all love meat—so the farmer must grow about twelve million head of beef cattle, and we consume a million head every month. Remember, it takes two or three years to grow a steer, and it takes a lot of feed and attention.

Pork furnishes one-half of the meat eaten by America and thirty per cent of the oils and fats. We butcher around seventy-five million head per year, which is over half a hog for each of us. The total consumption of meat this last year was equal to sixty-five million pounds each day.

These staple crops mentioned are only a part of the tremendous volume of food consumed by one hundred thirty million people, each eating three meals a day. The farmer doesn't deserve any special credit for manufacturing this supply, as it is his business and method of livelihood. His long-time success depends upon the treatment he gives his factory, which is his farm, and as we are all vitally interested in the productive condition of that land, we should be willing and anxious that he receive returns from his labor which will enable him to keep that factory in good condition.

Every particle of vegetable or animal food is composed of minerals and chemicals that can only come from the soil, air or water, helped by the sunshine, and it follows that these necessary ingredients will, in time, be exhausted if not replaced in some manner. They will run out just as your bank account will if you only use checks. Agricultural practices will either preserve or destroy civilization. Regardless of the attainments of men, the quality and quantity of their food will decide their destiny.

China was once a fertile country, but the crops, and the rain, and winds have left only enough for existence of the people who, as a nation, have gradually become weak physically, mentally and morally. North Africa was once a rich country—now most of it is a great desert. The Holy Lands, with the Garden of Eden, have gone the same way. India and other lands and peoples have gone through the same history. People deteriorate with the land on which they live.

Only in recent years have our people waked up to this danger facing us as a nation, and great strides are being made now to conserve and build up our soil. Terrible losses have already occurred which can never be replaced. There was a feeling until a few years ago that we had plenty of land and if we wore out one farm we could buy another.

The agricultural scientist who spends his life studying the soil sees it as the fundamental thing in all human activity. He knows that certain kinds of soil give rise to certain kinds of civilization, that men living in temperate zones growing crops on broad units will have different economic problems and have different attitudes of mind from men growing crops on smaller farms of poor land. The ingredients of the soil, a lack of this element, or an abundance of another element, affects the bodies of men, influences their glands, and, therefore, their psychology. Many human activities, not ordinarily associated with the soil, may be traced back to its influence. A stable, healthy and vigorous civilization demands a proper adjustment of men to the soil, and the soil resources should be so used as to maintain permanently the highest possible living standards for its inhabitants.

Recent legislation indicates that there is growing slowly a belief that the government should exercise its power and influence to preserve the fertility of our lands for posterity, on the theory that land is not just a commodity to be exploited by the current proprietor and owner, but should be preserved for future generations. The greatest physical

damage to this earth has been from erosion of our lands and was caused by either wind or water. The normal geological erosion that has gone on for ages under natural conditions is a part of the whole complex soil-making process. When man stepped in and cultivated land, he created conditions that resulted in an enormous acceleration of erosion, and this has brought about the most disastrous of evil things that could happen to our land.

Water erosion occurs chiefly on sloping land, but wind erosion on both level and sloping land.

The principal damage has resulted from rainfall on lands which have been plowed and cultivated. This applies particularly where the crop has been gathered and the land has been left with no cover protection at all. With no vegetation to hold the rain, every drop of water that runs off carries with it a little soil in solution and some of the valuable chemicals and minerals in the land, which gave the land its value. Raindrops are always clear and clean, but notice what they look like when they are running down the turn rows and the ditches, the creeks and rivers. Rainwater falling on a bare soil changes the structure and causes a compact surface layer which prevents penetration of the rain, which is then lost in the run-off. When water runs off, it not only does not deposit the valuable chemicals of the air and water in the soil, but carries off in solution the soil itself and chemicals which were already there. The extent and rapidity of this damage in the loss of the soil itself, as well as the chemicals and minerals it contains, depend upon the topography of the land, character of the soil, kind of cultivation, and the amount of the rainfall. The South is very unfortunate in that there is no snow to cover the lands in the winter as in the North. Snow protects land from erosion, and as it melts slowly, adds to the fertility.

Methods of measuring these losses of soil and fertility have been devised by the agricultural workers and the results are rather astounding. What is known as a lysimeter

is used to make these measurements. They are of various forms of construction, but are arrangements which, on definite areas, trap the soil washed off and the water run-off, both of which are analyzed and measured. These experiments are being conducted on all kinds of soils, with various crops, cover crops and bare land. The information obtained is so clear that our agricultural experts are able to tell fairly accurately how many tons of soil will be washed off per acre under certain conditions, and to give us the annual loss of the valuable chemicals and minerals which disappear in the water run-off. The outstanding and important fact developed is that on many farms where there are no cover crops, they are losing more fertility during the winter rains than were used up by the harvested crop.

In one series of experiments, the results indicate that on fine sandy loam land, the time required to strip seven inches of the more productive top soil would be from three to four thousand years, where properly covered with thick growing crops, whereas the same land cultivated without coverage and kept clean, would last from sixteen to fifty years. These figures were derived after actual measurements of the annual loss of soil. It is guesswork, of course, but experts estimate that it would take nature two thousand five hundred years to deposit or build up one inch of soil on land just from the rain, snow and dust in the air. Professor Russell, professor of Physical Geography at the University of Louisiana, places the silt discharge at the mouth of the Mississippi River at two million tons per day, or seven hundred thirty million tons per year. This is only one river. Authorities generally estimate that three billion tons per year are washed off our lands into rivers, creeks and bottoms. The scientists say this wasted soil contains sixty times the nitrogen and other elements of plant food used in commercial fertilizers in any recent years. At Dan River, Virginia, a dam was constructed in 1904 for power purposes, and the silt has already reduced the capacity eighty percent, and this experience is common over the country. Authorities

estimate that in the past one hundred years, our farming methods have resulted in the destruction of twenty percent of our land values.

In northern Mississippi, during a rain storm, measurements showed that land covered by forest lost seventy-five pounds of soil per acre. On adjoining, identical type land and which had been in cultivation with no cover crop, in the same storm, the loss was sixty-eight thousand pounds of soil per acre. Alfalfa land will absorb from four to five times as much water as the same land in open cultivation. Cultivated land, covered with straw enough to hide it, will absorb two to six times as much water as bare land.

In 1934, when the Soil Conservation Act was passed, the United States government made a survey and exhaustive study of the land situation of the whole country which covers one billion nine hundred million acres. This survey showed that—

3% or 57 million acres of original soil completely destroyed.
12% or 225 million acres of original soil three-fourths destroyed.
41% or 775 million acres of original soil ¼ to ¾'s destroyed.
37% or 700 million acres of original soil less than ¼ destroyed.
7% or 143 million acres of original soil mountains, canyons, bad lands, etc.

1,900 million acres.

The cropland area of the United States was about four hundred fifteen million acres. Of this, sixty percent, or two hundred fifty million acres, is of such poor quality that it returns only small income, or is subject to continued erosion, leaving forty percent, or one hundred sixty-five million acres, which can be safely cultivated under present practices. Department of Agriculture experts feel that around seventy-five million acres should be retired as not

suited for production. With proper and improved farming methods and practices, a large percentage of the land now being damaged each year can be added to the good, safe land, and this total raised to three hundred or three hundred fifty million acres. These figures do not include about one hundred million acres now in woods, pastures or improvable by irrigation and drainage, and which constitutes a great production reserve.

What are we doing to stop this damage? The most prevalent and important method is the use of cover crops to protect and enrich the soil. The next important method is the use of terraces, and contour farming, to hold the water and, third, in the country damaged by the winds, the use of windbreaks. Of course, in addition to these, there is diversification and growing of special crops fitted to the lands and territory.

Summer grown crops, when gathered in the fall, usually leave the surface bare and subject to the action of the rain and winds, and most erosion occurs at this time. Farmers are learning fast the value of cover crops, both as fertilizers and to protect the land from erosion, and the use of clovers, vetch, rye and other green winter crops is increasing yearly. Non-legumes furnish a large amount of foreign matter but use some nitrogen, but legume crops not only add foreign matter, but add the important element of nitrogen which is taken out of the air by the bacteria of the roots. Nitrogen phosphorus and potassium are the elements of greatest importance in the soil and can be lost by leaching, erosion and by crop plants. They can all be replaced by fertilizers or the growth of plants which collect and deposit these elements. Farmers are spending over two hundred million dollars per year for commercial fertilizer, in addition to the farm produced manure, cover crops, terraces and other methods used to hold the fertility of their lands.

Another successful and important method of fighting erosion of lands is the use of terraces and contours. On land

that is not level, these winding ditches and furrows, called terraces and contours, not only stop the erosion caused by the run-off of water, but collect and hold the water to enrich the soil. This practice is saving many farms which otherwise would soon be valueless. The government, through the Extension Division, is furnishing credit to groups of farmers to purchase and operate large terracing machines, as small farmers cannot afford to own them. Wherever you travel now in the country, you will see these curving, twisting furrows, winding around the hilly fields, and you may know that a good farmer is trying to save and hold his land.

Wind erosion is next in importance to water erosion, and affects millions of acres of our lands, particularly in the Western plains. Just a few years ago we had here in Memphis several sand storms originating in the Western plains that deposited a good layer of dust in our offices and homes, as well as outside. Our newspapers reported that one of those storms carried the dust over New York City and out into the ocean. The Department of Agriculture, in 1937, reported a sand storm which originated in the Panhandle and extended Northeast into Canada. Chemical analysis showed that the fine dust deposited on the snow in Iowa contained ten times as much organic matter, nine times as much nitrogen, nineteen times as much phosphoric acid as remained in the coarse dune sand which had been piled up and left behind at the source of the storm. So you can see that the good stuff was blowing away.

The greatest damage is not from these high cloud storms, but from the low blowing winds that carry the real soil away and pile it up where it causes damage and destruction. We have all seen little and large whirlwinds with a stream or clouds of dust going up into the air and apparently not coming down. Millions of acres of light land in the West which are only fit for grasses and pasture were put in cultivation in past years. When a storm and wind thousands of times in size and intensity to our little whirlwinds strike those bare acres of light, thin land, you have what are call-

ed sand storms. Wind erosion control depends upon setting up obstructions that will slow down velocity of the wind and covering the surface of the soil, so that fine particles of dust cannot be picked up and carried away.

Ten years ago the government proposed what seemed to most people an impractical plan to protect these Western lands by planting trees. I confess I thought so, but the results have been startling and I think the success of the program makes it interesting and instructive.

In 1934, the President, by Executive Order, allocated one million dollars from the five hundred twenty-eight million dollars appropriated by Congress for the relief of the inhabitants of the drought-stricken plains, for initiating the Shelterbelt Project, under the direction of the Forest Service. The primary purpose of the Shelterbelt Project was to develop wind barriers on farms in the plains to protect the soil and the crops. The first trees were planted in the spring of 1935 under a plan of leasing the planting sites. Beginning during the spring of 1936, the work was set up as a cooperative undertaking with the individual farmer, and the public has invested in this project, over fourteen million dollars. This program continued under emergency appropriations through the spring of 1942.

The project was operated over a large part of the six states of North and South Dakota, Nebraska, Kansas, Oklahoma, and the northern portion of Texas. As of June 1, 1942, a total of two hundred twenty-two million eight hundred twenty-five thousand two hundred twenty trees had been planted on thirty-three thousand one hundred eighty-five farms. These figures include eighteen thousand five hundred ninety-nine miles, or two two hundred thirty-eight thousand two hundred twelve acres, of field shelter belts.

On July 1, 1942, emergency funds formerly used to prosecute this project were virtually eliminated, but the Soil Conservation Service has retained most of the trained field personnel available on the project at the end of the 1942 fis-

cal year. Operating on soil and moisture conservation appropriations, this personnel is being used to direct and effectuate shelter-belt planting in soil conservation districts as an integral phase of complete farm conservation program. About ninety percent are expected to grow into acceptable windbreaks. After only three years, the protective influence was very noticeable. Lands and crops are being protected as well as livestock, feed buildings, game, birds, etc. The Soil Conservation Division feel that the program has been a success.

How to use land better than we have is a national problem. The physical well-being of future generations must be secured if the nation continues to live, and one of our great national objectives should be to pass on to our descendents, the soil as unimpaired as possible.

The national interest and the individual interest often conflict, as farmers sometimes find it necessary to do things to the soil that are not for their own long time interest, or in the interest of posterity. Some types of farming conserve the soil naturally. Tenant systems tend to destroy fertility as the tenant hasn't the same incentive that the land owner has. He has rent to pay and his own living expense, so he, naturally, digs all he can out of the land and puts little back. Low prices for farm products also force farmers to violate the good rules of farming, because of lack of funds.

Submarginal lands, unfit for farming, should be taken out of cultivation and be allowed to grow up in timber or grasses for pasture. These lands compare to city slums and can never support farm families in a decent manner.

Even with the shortages of labor, lack of fertilizer and insufficient machinery, the farmers of this country have, in the past two years, exceeded the quotas set by the Department of Agriculture. The job ahead is to properly feed this country and help feed the millions of people in the Allied and occupied countries, and we must plan and make every effort possible.

All told, last year the United States produced enough food for three times our population, if crops had been fed directly to human beings. It takes about seven pounds of corn to produce one pound of pork and eighty-four percent of the energy of grain is lost when turned into meat, so the number of people we can feed, depends on willingness to do without meat.

On March 30, 1943, the President of the United States, sent through diplomatic channels, to all the United Nations and nations associated with them, an invitation to a conference on foods and essential agricultural products, which was held in Hot Springs, Virginia, in June, 1943.

The text stated it was the opinion of the United States Government that it was very desirable now for the nations associated together to begin joint consideration of the basic economic problems with which they and the rest of the world will be confronted after the close of the war. Each nation was invited to send a small number of appropriate technical and expert representatives.

The purpose of the conference was to provide for an exchange of views and to seek agreements in principal as to most desirable and practical means and methods of dealing with the following problems:—

1 Plans and prospects of the various countries for the post war period regarding production, import requirements and exportable surpluses of foodstuffs and other essential agricultural products, with a view of improving in each country the levels of consumption within the framework of the opportunities and possibilities of an expansion of its general economic activities.

2 Possibilities of setting up international agreements and institutions designed to promote efficient production and insure for the world, adequate supplies at equitable prices from the viewpoint of both producer and consumer.

3 Commercial and financial arrangements necessary to enable countries to obtain agricultural products and also maintain adequate markets for their own surplus production.

4 Possibilities of stimulating by international action, national policies for the improvement of nutrition and consumption in general.

The conference was attended by representatives of forty-four nations and there was set up a permanent organization. The newspaper fraternity felt that the conference directors had slighted them and treated them discourteously, and became greatly offended. In retaliation, they belittled and ridiculed the proceedings and have never given it the publicity which its importance deserves.

The conference and the possibilities from it can result in great help to the whole world. An interim commission was appointed and is now sitting in Washington gathering and tabulating information about food supplies and food needs of all nations. With all the facts before them, the several nations can more efficiently and economically trade and distribute their food supplies when the war is over. Remember, we import a lot of foods, so it is not just a plan to give away our own food.

In conclusion—I believe our great national problem is to so adjust the use of our lands, that the needs of civilization may draw on them continually and that the land in turn be preserved and enriched as nature demands. Costs of food must be such that the farmer can prosper and that people in industry can be protected and provided with sufficient healthful food.

Always we must remember that our form of government, our freedom and our future of tomorrow rests in the soil of the United States, and that the crops from the harvested acreage will determine employment, prosperity and expansion of our nation.

CHAPTER VIII

Soil Mineralization

Parks' Soil Service, Keene, Kentucky

Implies a new Era in the use of scientific knowledge, and intelligent and diligent work in restoring our depleted soils to their maximum productiveness, then using them as a vital force to restore health to the human race, first—by analyzing our soils for the kinds, amounts, and preponderances of the mineral elements found in them, and then striving to build them to the highest known standard, by locating, moving, grinding and mixing the twenty-five or more mineral elements taken from Nature's own resources and applying them to your soil and food source for each individual need.

It is applied to the depleted soils of our gardens by scientifically giving each a careful synthetic test, and recommending the use of the many mineral elements found deficient, and prepondering those elements most needed by the vegetables commonly used for human consumption. All other depleting crops and grasses are given the same individual attention by prepondering those elements which the plants are capable of using most effectively and storing as nutritious food.

All life—atoms, bacteria, plant, animal and human—is now controlled accidently, but can be controlled intelligently by the kinds, proportion, preponderance and physical arrangement of the many mineral elements contained in our soils as available plant food. Therefore if any of the essential mineral elements are continuously deficient in our daily diet, we are forced to live without them until some human deficiency developes namely Hidden Hunger, which is incurable, except by Nature's own way of using the plant as the source of organic minerals, which acts as preventative measures at all times.

It has passed the experimental stage, has already proven practical, and can now be obtained at "Parks' Soil Service," Keene, Ky., by sending us your soil sample, accompanied by the size of the area to be treated and the use to be made of the treated area, after which Parks' Soil Service will give you a free estimate, then furnish you a complete mineral mixture as recommended. Also available now are many mineral standard foods of various kinds, which are especially recommended for the use of doctors and dietitians. And those we do not have we will glady give reference to the producer of same.

A few of the limiting factors in the production of this Standard Soil Builder are: the urgent need of capable and experienced soil chemists, who can test our soils for the twenty or more rare elements and make the required recommendations; the increased demand has necessitated the immediate need of a more modern mixing plant; the varied sources from which the raw materials are gathered, requiring more labor, equipment and capital; and the need of a more extended publicity campaign to encourage the production of Mineral Standard Foods, and to urge the market gardeners to have an adequate supply available at all times for the consuming demand.

We also sponsor a "Live More at Home" program and live better because of life sustaining foods used in the daily diet and gathered from a Mineral Standard Garden. And we urge the need and importance of every diligent gardener to have his Soil tested and Mineral treated, or else rotate that garden plot to avoid unfavorable conditions that most often exist.

We also discourage the excessive use of rich barn-yard manure and commercial fertilizer without a balance of other rare Elements to safeguard ourselves from many of the most common afflictions. Let us keep in mind that we are all human machines, created in the image of God and fashioned from the kind of material elements that we get from

Mother Earth through our food intake. In other words, we are what we are, because of what we eat, and the manner we prepare and eat it.

In accord with latest methods of scientific soil building, and under the supervision of the most experienced soil chemist, Parks' Soil Service is attempting to gather from all parts of the world the many elements most needed, and striving to get them from natural resources so far as possible. Much more is yet to be discovered and we are hoping to find all of the twenty-five or more elements used, stored somewhere in nature, which can be obtained at less cost. At the present time we are using the most useful ground rocks, organics from the vegetable kingdom, the major elements contained in commercial fertilizer and several of the concentrated chemicals, which are used in smaller quantities.

Parks' Soil Service is sparing no effort in erecting the most modern mixing plant in the world today, for the sole purpose of more effectively serving the many needs of humanity. Especially by offering a substitute for Hidden Hunger and also supplying the Hereditary requirements at the root of all Nutritional plants. Therefore we are rendering a special service in restoring the most depleted soils to their former productiveness, and also supplying to the needs of suffering humanity the many elements most needed to restore them to normal health through their food source.

All persons interested in the new possibilities of their soils, by the creation of a new wealth to meet the present emergency in the consumption of better Mineral balanced foods or in restoring to good health those who have fallen a victim to some deficiency disease may write or call, and we will gladly furnish free any information in regard to any of the above statements. Also a good General Purpose diet (80 percent - 20 percent) will be given those persons interested in keeping healthy or aiding the afflicted to become normal.

Mineralization

A term which comprises all the good practices of the most exact Soil builder, the use of the seven or eight essential elements recommended by both Soil building Experts and Fertilizer manufacturers, and in addition: recognizing the presence or absence of, admitting to the importance of, and recommending the use of twenty other rare elements in minimum quantities.

All life is controlled through the Soil, and can be intelligently controlled by a liberal use of plants grown on Soil, which has been tested and supplied with the many essential elements that build bone, muscle, cell, gland and other vital organs of the body.

The application of this term, if applied in specific cases of deficiency disease, will result in a permanent cure, or a prevention against other serious troubles that might develop.

"FOR HEALTHS SAKE MINERALIZE YOUR GARDEN" and avoid the liability of falling prey to many common diseases, which exact a large death toll.

Share in an Educational and Live More At Home campaign sponsored by PARKS' SOIL SERVICE, Keene, Ky.

CHAPTER IX

The Minor Elements Play No Minor Role in Florida

HAROLD MOWRY
Director, Florida Agricultural Experiment Station in Farm for Victory
The Citrus Industry, August, 1945

Florida's soils, although quite varied in type, are considered deficient to a greater or lesser degree in one or more of the elements necessary for optimum growth in cultivated plants. While the requirements for nitrogen, phosphorus and potash have long been known and the need supplied in the regular fertilizer program, the use of the so-called minor, trace or secondary elements is a signal development of recent years.

The minor element deficiencies vary in kind and amount and their diagnosis has been anything but simple owing to the wide diversity of soils and crops and the variation in requirement for the several elements by the different plants. Recognition of the many deficiency symptoms and development of corrective practices constitutes an interesting and significant chapter in the State's agricultural research history and has resulted in the widespread adoption of a new conception of plant nutrition under field conditions. Until the past few years, our fertilizer recommendations included only N-P-K requirements. For many crops, these programs were subjects of wide experiment and diversity of opinion owing to the lack of stability and uniformity in results. Despite ample application rates there were unsatisfactory growth responses and with some crops and in some areas, a decline or partial failure in vigor and productive capacity.

Widespread and varied abnormal growth conditions indicative of a lack of thrift, which were non-pathological and on the whole uncontrolled by N-P-K fertilization, were described as "physiological"—cause unknown! Various ratios, sources and application rates were both praised and condemned, there being no generally uniform or continuing wholly satisfactory response.

The vital role of the minor elements under field conditions was not suspected and it was not until their need and values were determined that the limitations of N-P-K fertilizer were demonstrated. It is not that N-P-K requirements are reduced by the use of the other elements; but rather that the efficiency of the major fertilizer elements is enhanced in ratio to the reduction of limiting factors induced by minor element deficiencies. Normal utilization by the plant of nitrogen, phosphorus and potash appears to be dependent in no small measure upon the satisfaction of the associated requirement for other nutrient materials. While the interrelationship of the functions of the several elements in plant nutrition is far from being completely understood, the increased yields, vigor of growth and disappearance of "deficiency symptoms" have established the essentiality and practical values of many elements in the fertilizer program which only a few years ago were given no consideration.

It is not to be taken that all plants on all soils require supplementary fertilization with all minor elements. Many of the cultivated plants under most conditions may show no measurable response to any of them; some may respond to one or more but only on given soils; while others require from one to several on a wide range of soils.

Deficiency symptoms and application rates and methods have been determined for one or more of the six elements—copper, zinc, manganese, magnesium, boron and iron—on citrus, tung, corn, pecans, peaches, avocados, mangoes, celery, beans, tomatoes, potatoes, pasture plants and numerous

ornamentals, with the list increasing. Few crops would be grown on the organic soils of the Everglades without copper, and the tung tree is a failure in many areas without zinc. Heavy annual celery losses due to "crack-stem" were entirely overcome with boron, while carpet grass sod with a single application of a combination of copper, zinc and manganese was established in a few months where ordinarily two years would be required. Citrus nutrition practices have undergone a pronounced transformation and now include zinc, copper, manganese and magnesium and occasionally boron and iron. This program has been adopted generally and has resulted in markedly greater production and improvement in tree appearance and growth as well as increased resistance to cold damage and improvement in fruit quality. On a wide variety of fruit and nut trees, vegetables and ornamentals, minor element deficiencies are the direct cause of "physiological diseases" which were marked by a baffling lack of thrift and chlorotic or malformed foliage and, with some, low or alternate bearing.

Appreciation of the values of the minor elements and of research on their use may be gauged by the magnitude of application. During the 12-month period ending June 30, 1944, Florida consumed for agricultural purposes some 19 million pounds of copper sulfate, nearly 23 million pounds of manganese sulfate, some 3 1/3 million pounds of zinc sulfate, and large quantities of magnesium, the last in the forms of sulfate of potash-magnesia, magnesium oxide, and dolomitic limestone. When the small application rate requirements per acre are considered, these poundages give some idea of the extent of the treated acreage involved. Last season, Florida produced over 260,000 carloads of quality fruits and vegetables. While by no means wholly responsible, the minor elements played no minor role in that accomplishment.

CHAPTER X

Pasture Grass Improved by Adding Minor Minerals

By J. CLEMENT BROSSIER
[Editor, The Orlando Reporter-Star]
The Sunday Sentinel-Star, Orlando
August 13, 1944

The value of minerals in the diet of cattle, and the importance of adding the minor minerals as fertilizer to the soil as a pasture builder is being interestingly brought out in experiments on the Range Cattle Experiment Station, 15 miles southwest of Wauchula under the direction of Drs. W. G. Kirk and E. M. Hodges.

In 1935, persons interested in cattle husbandry started a movement to provide a range and experiment station in Hardee County to promote the raising and breeding of cattle as well as to learn more about improving pastures. This group advanced funds which were added to by the County Commissioners and later an Act of the 1937 Legislature made it eligible for Federal assistance by making the work a WPA project.

Actual work on some 2,000 acres of land got underway Jan. 12, 1941. As the land was the typical lowland flatwood it was necessary to dig a canal and do other preparatory drainage work. A few buildings were constructed including a home for the Kirks, and a soil survey made on the 1,000 acres of the land under fence.

In October native and grade cattle were procured and the work began in earnest. However, the war has greatly handicapped its operations due to a scarcity of labor, funds and materials.

But Drs. Kirk and Hodges have done an excellent job working under their handicap. Charts of the work have been kept and furnish an excellent record of the response cattle and grasses have made to the methods used.

One of the most interesting facts developed in the experiments is the varying amounts of additional minerals required by cattle in their diet during the different seasons. For example, when the native grasses were succulent in May the cattle consumed but a half pound of minerals in the salt-lick mixtures. This amount increased as the pastures became older and the grasses dryer until in January the consumption was 5.38 pounds per cow. This amount then began to diminish until June. The total consumption for the year amounted to 24.65 pounds per cow.

While all cattlemen know their stock loses weight during the Winter months, few know exactly how serious this loss is.

Cattle are weighed at the station every 28 days and an accurate account of their condition is ascertainable at all times. Reaching their peak weight at the end of the Summer months after Spring grazing, the loss in weight to midwinter in many instances ran to 300 pounds, while an average was around 200 pounds.

This means that cattle must gain 200 pounds or more after going through a Winter before there is a net gain over the high weight of the previous season.

However, it was demonstrated that a small addition of feed fed in connection with the pasture cut the loss to a minimum. Experiments wherein 4.9 pounds of blackstrap molasses per cow was fed produced a gain from December to April of 35 pounds; 10.5 pounds of fresh sugar cane put 52 pounds on the cattle but 1.72 pounds of cottonseed pellets added 82 pounds per cow over the same period.

The value of breeding native and grade cows to pure-bred

bulls was demonstrated in the results of a cross between a Hereford bull and a grade Devon cow. The offspring weighed 400 pounds at four months. A cross from an ordinary Jersey milk cow and a Brahma bull produced an offspring of 175 pounds at six weeks.

Approximately 2,000 cattle have been acquired by the station, which includes purebred Brahmas. Most of the breeding will be to the Brahma bulls in the future.

Also of value to the cattleman is the information being gathered about pastures.

In this respect the experiments of Drs. Kirk and Hodges are proving the degrees of value certain fertilizers are to different types of grasses.

The pastures which are showing the most response at the present to fertilization are those sown to digitaria and carpet grass.

The soil used in the experiments is the Emmokolee much the same as the Leon soil found in most of Florida's flatwoods. Although the soil tested extremely low in zinc, the addition of an application of that mineral based on 15 pounds to the acre showed little results. However, an application of copper sulphate showed excellent results and when the copper and zinc were combined with manganese each on a basis of 15 pounds to the acre, the results were remarkable. The Digitaria, which is much like crab grass, sent out runners as long as 12 feet and grew waist high.

The carpet grass did not respond as readily as the digitaria to the minor elements treatment without the added application of commercial fertilizer, but with the addition of a 3-16-8 fertilizer a five acre pasture two seasons old had reached almost a lawn sod, while other pastures, prepared and seeded in the same manner but on which either no fertilizer had been used, or only rock phosphate, the grass was spotty and in very sparse quantities.

The differences between the fertilized pastures and those not treated demonstrated most conclusively that the one application of food to the soil will bring in pastures two to three years ahead of unfed soils and with far greater carrying capacities.

Other grasses experimented with at the station are the Pensacola bahia, the ordinary bahia and lespedeza. The bahia types show promise but are not as encouraging as either the carpet or digitaria, while the lespedeza seems unable to successfully combat the natural growth, but experiments with this legume are still going on.

Such Winter grasses are dallis, para and sugar cane are also being tested with varying degrees of success.

The work being carried on at the station is most interesting and should provide cattlemen with definite information on pasture cultures.

CHAPTER XI

Notes on Animal Nutrition

Hoard's Dairyman, August 10, 1945

> "We are simply trying to unravel the story of animal life from the nutritional side. We do not expect to get very far but we hope it will encourage others to work in the same direction in order that we may have more fundamental understanding of the principles of animal nutrition than we now possess."

These words were spoken to us thirty years ago by Professor E. B. Hart when we visited him at the Wisconsin Agricultural Experiment Station. We used this quotation as the introduction to a report under the above title that we made of that visit to the readers of Hoard's Dairyman. It was essentially a story of important researches that had recently been completed.

Briefly, it included the findings that rations fully balanced according to chemical analysis might not properly nourish the animal. It showed that the variety of proteins, as well as the amount, was highly important. Based on these investigations and the report of new ideas was the then recent discovery of fat soluble A and water soluble B, which were the names originally given to vitamins as then known. This represented a new era in the investigation of livestock nutrition and was a startling promise of further research that has accumulated in the some thirty years since that time.

We now make a report of another visit with Professor Hart that we made a few weeks ago. Before making this report, however, we might add that Professor Hart came to Wisconsin from the Geneva Station in 1906 and succeeded the veteran Babcock as chairman of what is now known as

the Biochemistry Department of the University of Wisconsin. This may seem like a rather formidable title but the man is the same practical, farm-minded scientist today that he was when he came to Wisconsin. Biochemistry is simply the chemistry of plant and animal life. Professor Hart has recently retired as head of his department but the University has been fortunate in keeping him as chairman of the Research Committee for the entire University.

The following notes are not intended to be complete or even brief discussions of the several topics covered or to assess their relative importance. They are merely introductory and are given to indicate the breadth of research that is going on today, not only at the University of Wisconsin but at all the universities maintaining agricultural departments.

While these notes are based on our conversation with Professor Hart, he would be the first to be emphatic in saying that the results achieved were the work of many men in the department which he has supervised for thirty-two years, and were often secured by the cooperation of other departments at the University.

Butterfat

New research has added new laurels to butterfat. Feeding trials concerning vegetable oil and butterfat indicate that the latter has a certain beneficial effect on the efficiency with which intestinal bacteria can synthesize the B complex vitamin. This is particularly true where the carbohydrate portion of the ration is supplied by lactose as is true with children living largely on milk. This finding serves as a warning against the use of filled milk in which the butterfat is replaced by cheaper vegetable fats.

Protein

People for years have talked about the value of proteins in the diet, but the real need is now disclosed to be for certain amino acids of the proteins in adequate amount and in

suitable balance. The protein of milk is, perhaps, the finest and best balanced source of the amino acids of protein, but other excellent sources are found in the red meats. Grains generally are low in certain of these essential amino acids. It is held by some that the animal proteins are valuable additions to the ration of the dairy cow, fish meal being one of the most commonly used for this purpose. In the feeding of hogs the superiority of milk, tankage, and meat scraps has been recognized for many years. Indeed, they are recognized as practically essential if hogs are to be grown most economically.

Manganese

Manganese is normally found in the stems and leaves of plants, but is low in such grains as corn. Two groups of calves were fed identical well balanced rations except that one group's ration was low in manganese. For a time both groups grew well and all were bred at normal time. The group fed the ration containing manganese produced full time calves and milked well. The other group produced premature calves and were not thrifty. The indications were that one difference in these two lots of calves was due to the fact that the manganese enabled these heifers to produce a larger amount of the essential vitamin C. These trials also indicated that the feeding of manganese seemed of some help in controlling acetonemia. When additional manganese is indicated as desirable, it is fed at the rate of approximately seven ounces of manganese mixed with one hundred pounds of salt.

Cobalt

It is only in recent years that it has been found that in a few limited sections of our country young cattle suffer from the lack of the mineral cobalt in their ration. The animals go off feed, become gaunt, may be sexually under-developed, and suffer from anemia. This has been particularly noticeable in some sections of New Zealand, Florida, Michigan, and along the upper eastern shore of Wisconsin where dolo-

mitic limestone underlies the surface soil. It should be noted that if cobalt is added to the ration, it is injurious to use it carelessly or in too great amounts, although cattle seem to tolerate moderate overdoses better than some other animals.

A simple way to give this mineral where it is indicated as desirable is to add one ounce of cobalt sulphate to each one hundred pounds of salt given cattle. It should be remembered that the cobalt will not be of any value if the trouble affecting the calves or cattle is due to the lack of good feed or the lack of other minerals.

Blood Building

It takes six to eight weeks to regenerate human blood after hemorrhage or even after a one-pint blood donation. Work with animals shows that a week or less is time enough provided the diet is suitable. This is true even when as much as a quarter of the blood has been lost. Riboflavin (vitamin B_2) is highly important in determining the size and rate of formation of new blood cells. While this is the newer approach to the question, previously known requirements for efficient blood regeneration are the intake of ample protein, iron, copper, and one of the B complex vitamins known as pyroidoxine.

Early Cut Silage

When cows were fed corn ensiled late in the season it was found that the vitamin content was about half what it was when they were fed grass silage. Later trials indicated that the vitamin content of the silage was improved if the corn was ensiled when the majority of the kernels were past the milk stage but were not in the hard dough stage. In a comparative trial with this newer silage one group of cows was fed 40 pounds of corn silage and the other 40 pounds of alfalfa silage preserved with corn meal, other feed being the same for both groups.

Assays of the feed showed that cows in the alfalfa silage

group received about two and one-half times as much carotene as those on corn silage, but the milk they produced was only 25 per cent higher in vitamin A and 20 per cent higher in carotene. The higher carotene content of the alfalfa silage produced a higher vitamin milk but the vitamins in the milk were not in proportion to the carotene content of the silage.

It was also noted in this trial that the superiority of the early cut corn silage as a source of high vitamin milk was much better than in the previous trials when corn that was much more mature was the source of the corn silage.

Anti-Scours Vitamins

Pharmaceutical concerns are now marketing vitamin capsules for use in preventing scours in young calves. This is a difficulty that is experienced quite frequently in calves born after the first of the year when the vitamin A content of the milk and the hay is probably at its low point of the year. The formula provides for the use in each capsule of 5,000 international units of vitiman A, 50 milligrams of niacin, 250 milligrams of ascorbic acid (vitamin C), and 200 international units of vitamin D.

It is to be remembered these vitamins are not cures for scours but are essentially preventives to use before the calves become sick and, preferably, immediately after birth. They may be of some help if given promptly at the very first sign of scours, and should be used when the trouble has been occurring with other new born calves. Young calves cannot utilize carotene in hay as well as vitamin A, which may explain the prevalence of the opinion that at times it is harder to raise calves from breeds producing high color milk than from other breeds.

Sulfa Drugs and Vitamins

Experimental trials have shown that vitamin C has been helpful in controlling nutritional calf scours. Other trials

have indicated that certain sulfa drugs are useful in treating infectious "white scours." It has now been shown that these certain sulfa drugs tend to increase the vitamin C content of the blood which indicates that it may really be the vitamin C that is the controlling factor.

CHAPTER XII

Soil-Builders

Florida Finds 'Trace' of Minerals Put New Life In Old Citrus Trees
Magnesium Builds Green Leaves; Manganese, Boron And Zinc Increase Fertility
Orange, Grapefruit Crops Up

By VICTOR SCHOFFELMAYER
Special Correspondent of The Wall Street Journal

Seven common minerals added to Florida's soil have brought the state a three-fold increase in its biggest cash crop, citrus fruits.

Five of these minerals are used in such tiny amounts that a chemist couldn't calculate their proportion to the soil; he would have to put down "trace."

The trace elements are copper, iron, manganese, boron and zinc. With sulphur and magnesium they make up the seven minor elements whose praises are sung by all the firms that sell fertilizers in Florida. Plant-life must have all seven of these elements to thrive, although they have been ignored for nearly a century in formulating the so-called "complete" artificial fertilizers.

In 1932-33, with production of citrus fruit below 30 million boxes, some growers feared their industry was almost done for. Traditional fertilizing with nitrogen-phosphorus-potassium mixtures, even on a lavish scale, was powerless to build up yields beyond 100 pounds a tree. Growers accepted the theory that citrus land mysteriously "played out," and that there was nothing to do but move onto new land and plant more trees.

Finding Capital Not Easy

Finding capital for such an operation wasn't very easy, for the depression was at its worst. The state had taken heavy financial and physical blows from the land boom of 1922-26 and the September hurricanes of 1926 and 1928.

In the 1944-45 season, the citrus crop totaled over 90 million boxes. The grapefruit pack, 23 million boxes, passed the combined packs of Texas and California. Most of the fruit came off the same acres that had been despaired of 12 years before. And the industry's comeback led to the planting of 50,000 acres to new trees last fall and winter.

Much of the credit for the citrus industry's rebirth goes to Dr. A. R. Camp, vice director of the State Citrus Experiment Station at Lake Alfred, Fla. He came to Florida in 1935 from California, where he had worked on citrus fertilizing, and began building up the Florida groves with the trace elements.

Magnesium gets at the very heart of the citrus grower's problem. It makes possible the formation of chlorophyll, the substance in green leaves that captures sunshine and transmutes it into orange juice and halves of grapefruit.

Iron is another essential component of green leaves.

Manganese, boron and zinc increase the fertility of a plant; more individual fruits are formed.

These minor elements are not needed in quantity. One part of boron in 10 million of soil is about right; one part in 5 million may be toxic.

Sulphur, becoming greatly diluted sulphuric acid in the soil, helps the soil bacteria to digest organic matter for the plant's roots to absorb.

Nitrogen, phosphorus and potassium, the big three, are still vitally needed; to them calcium is added, making a big four.

Nitrogen builds foliage and retards ripening. The plant seeks to get as big as it can before it reproduces itself.

Encourage Root Growth

Phosphorus encourages root growth. It speeds the storage of nourishment, and thus hastens the ripening the nitrogen seeks to delay. Magnesium comes back into the picture here. Somehow it moves the phosphorus from the old cells where it has done its work, into new cells that need its help.

Potassium gives a plant stamina. A potassium-poor plant is the first to be blighted or attacked by parasites.

Calcium strengthens stem and root cells, the frame of the plant, just as it builds sturdy bones for human beings.

The suspicion that the big three elements—nitrogen, potassium, phosphorus—of "complete" fertilizers were not all the foods that plants needed is almost as old as the artificial fertilizer industry itself. In 1866 two Germans grew wheat in well-water solutions of artificial fertilizers and natural manures, and concluded that plants couldn't thrive by chemistry alone.

Experiments by U. S. Agency

Between 1900 and 1910 the U. S. Department of Agriculture carried on a series of experiments on organic and inorganic plant foods. These experiments established the limitations of inorganic fertilizers, and gave new emphasis to the factors in soil improvement quite aside from any nutrient material—soil bacteria and the fertilizing factors we have come to call auxins, hormones and enzymes—that help the plant to utilize what nutrients are there for it.

Reading accounts of those 40-year-old experiments, it is easy to see today that the Department of Agriculture researchers crossed the trail of the trace elements, probably more than once, and lost it again through the difficulties of soil analysis. Soil analysis through purely chemical means is tedious drudgery, prone to error when the components

sought are very small. Chemical analysis has now been reenforced by spectroscopy. The spectroscope unerringly spots unbelievably small concentrations of any element in a solution.

As long as the sources of artificial fertilizers were natural rock, it didn't make a great deal of difference whether anyone knew about the trace elements or not, in the case of most soils. North African rock phosphate, turned to superphosphate, carried calcium and sulphur as well as phosphorus into the ground. Chile nitrate contained boron as an impurity.

But when ammonium phosphate began to be made from atmospheric nitrogen and metallic phosphorus, neither boron, calcium nor sulphur went along as an extra dividend.

Much soil contained the trace elements in sufficient quantities, carried there as dust by the wind. Florida was unfortunate. A 500-mile peninsula between the Gulf of Mexico and the Atlantic Ocean, it could only receive dust when the wind blew from one point of the compass.

After Dr. Camp and his co-workers taught the Florida citrus growers how to get the essential minor elements into the soil, the next thing to do was to help the trees get it back out. There is a 50- to 70-inch annual rainfall in the Florida citrus country, but little of the rain remains in the sandy soil. So now extensive irrigation systems keep the trees growing through the dry spells of spring and fall. A survey of 1,200 groves in 1942-43 showed an average return of $3 an acre on non-irrigated groves, $45 an acre on irrigated ones.

Last year Florida bought 23 million pounds of dolomite—calcium magnesium carbonate — from Texas, 22 million pounds of copper sulphate from the Southwestern mines, and 3.5 million pounds of zinc sulphate from Missouri smelters. The other minerals were applied in lesser quantities.

Some were sprayed onto the trees. Tennessee Eastman Corp., a subsidiary of Eastman Kodak Co., is a supplier of magnesium sulphate for spraying.

As an object lesson for any citrus grower who might forget what he has been rescued from, the 120-acre experimental grove at Lake Alfred has been divided by a road. On one side traditional care has been applied to the trees. Their yields range from 50 to 100 pounds of fruit to a tree. On the other side, trees generously fed with magnesium, iron, copper, manganese and boron by the Camp formulas are weighted down with from 600 to 1,000 pounds apiece.

CHAPTER XIII

Some Symptoms of Citrus Malnutrition in Florida

By A. F. CAMP and B. R. FUDGE

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One of the outstanding recent developments in the field of citrus nutrition has been the utilization of the symptoms found on leaves, twigs, and fruits as guides in fertilization. Research which has revealed the specific relationship between nutritional requirements and certain symptoms exhibited by the citrus tree has furnished the basis for this development. Thus it has been found that zinc is a specific remedy for "frenching" and copper for "dieback" and that neither will fill the role of the other. Likewise, deficiency of either manganese or magnesium will give rise to certain definite symptoms in the citrus tree, whereas an excess of boron will produce equally specific symptoms which are characteristic of the toxic effects of this element. These symptoms have proved much more specific than at first supposed and serve as excellent indicators of the tree's nutritional needs. The idea of using an element as a specific remedy for a particular set of symptoms is not entirely new, since copper has been used as a specific for "dieback" for many years.

In Florida nitrogen deficiency has been generally accepted in the past as the cause of practically all yellowing of citrus leaves and it is only recently that the various types of yellowing have been adequately classified with the result that magnesium deficiency is now recognized as the cause of the commonest type of yellowing. Much of the

progress made has resulted from more detailed and critical observation of the trees themselves; and the practical utilization of symptoms as a guide in citrus nutrition requires equally careful observation, particularly when symptoms of several different types are combined in such a way as to mask partially one or more of them.

Work In Citrus

The great citrus industry of Florida is gradually being given the benefit of this scientific, fool-proof data. The rapidity with which results may be obtained will be astounding. The results seem revolutionary, yet no one class is suffering at the expense of another. This is one thing just as important to the consumer as the producer.

Zinc, magnesium and copper are most widely deficient in most of the grove soils in Florida. This is combatted with corrective fertilizers, and in some cases, with proper sprays. Of course, only the surface of this practice has been scratched, knowledge has not yet been spread around like the daily news.

Where partial knowledge is applied, the results can be partially injurious. Increasing the amount of potash will not replace the zinc and magnesium absent in the particular plot. Increasing the nitrogen, will not insure a balanced growth and development, or a proper flavor, where these minor elements are absent. On the other hand, once the zinc, magnesium, and Copper have been added in sufficiency, the great amount of nitrogen, mistakenly applied formerly, may prove excessive.

The proper information is waiting to be used, used for the benefit of the consumer throughout the nation.

Minerals That Turn The Wheels Of Life

Minerals play a role without which motor force and connection between the glands would break down. Physiologists can not conceive a body without the mineral elements making bone, nerve, blood and brain, nor psychologists a

conscious mind without mineral elements. Even poetry cannot find its material without the proper combination of mineral elements, or art its shape, form, essence and color; actually there is nothing we can conceive, from trees to plants to animals, building material to evening gowns, that does not depend on a proper combination and amounts of the various kinds of elemental minerals. Whether alive or dead, in many things the difference depends on the proportionate amount of the elements, and the resultant radio activity.

As the mineral salts are the controlling elements in organic life, so are they in glandular life, therefore in psychological life. They are potent factors to be considered in all sociological and eugenical development.

From MINERALIZATION—by Albert Carter Savage.

Surely the great body of organized science that developed Radar, the Clycotron, Dark Light and Spectroscopic analysis and released the atomic energies in the form of the LIFE-destructive atomic bomb can give us speedy quantitative and complete tests for the amount, kind and concentration of the mineral elements in the total soil and water food sources of the world, so that the standardization of this primary source point of Life's development, healthy well-being and genetic possibilities can be speeded up with the increasing and vital need for lightening needless burdens in man's race against time for betterment NOW.

By—Albert Carter Savage.

CHAPTER XIV

The Effect of Agricultural Practices on Health and Disease*

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It is the purpose of this paper to correlate some recorded observations, and interpret them, in terms of possible etiology, of the health and some of the ills of man. Minot states: "It has been proved that certain diseases reflect the character of the social and economic as well as the geographic environment." Snapper indicates that every phase of clinical medicine in Peiping is influenced by the peculiar food situation. One might add that health, too, reflects the character of the social, economic, and geographic environment.

The correct diagnosis and therapy in deficiency diseases has been one of the advances of medicine. However, our desire is the prevention of these deficiency diseases. Although much has been accomplished, there are still many unknown factors in the field of nutrition and its relation to sickness and health.

The medical journals have many papers telling of recently acquired knowledge on almost every variety of deficiency—avitaminosis, hypoproteinemia, and mineral imbalance, with therapeutic response when therapy is based on the proper rationale. There are perhaps no doctors more aware of the value of rational vitamin, mineral, and food concentrate therapy than we in neuropsychiatry. However,

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the absence of the progressive degenerative disease of the blood vessels—arteriosclerosis; or the progressive degenerative disease of the nervous system—multiple sclerosis—among the Northern Chinese, whose diet is inadequate in those things we can determine by laboratory analysis; namely, calcium, vitamins, calories, suggests that limited vitamin, mineral, and caloric value is not etiological of these diseases. They have their avitaminoses, their hypocalcemia even to the extent of osteomalacia, but not arteriosclerosis and multiple sclerosis as do their better-fed friends in Continental Europe, England and America. When their food is biologically assayed, who are better off—the Orientals or the Occidentals?

Are the agricultural practices of the Orient and those of Germany, for instance, the reason that multiple sclerosis is unseen in the Orient and so common in Germany? Natural manures have been used in the Orient for centuries, while chemical fertilizers have been championed by the German school of agriculture since 1840. Is this type of soil fertility a factor in giving a food to the population, which, in turn, tends to give them an immunity to arteriosclerosis, thrombophlebitis, multiple sclerosis, Gaucher's disease, renal calculi and gallstones—an immunity which the Chinese seem to have. Does the Oriental agricultural practice give an x value to food that makes its biological assay high in spite of the Chinese diet being low in chemical assay?

Does it follow that people who have an adequate diet will not have deficiency diseases, and, furthermore, may have better natural immunity to disease? The question that presents itself is—what is an adequate diet? Until the present the emphasis has been on the quantities of vitamins, minerals, proteins, fats, carbohydrates, and not on the quality of foods. We may be instructing our patients to ask the questions—how fresh is this food? From where did this food come? What was the nature of the soil fertility that grew this produce? Were natural manures or commercial fertilizers used on the land? What was the fungus and bacteria

growth in the soil that grew this food? Was this vegetable grown on a mycorrhizal or non-mycorrhizal soil? What was the quality of the food fed this veal or that beef?

This question of food quality was brought to my attention by Colonel Henry W. Anderson, a lawyer by profession, a scholar by nature, and an agronomist by avocation, when he told me of his observations and presented me with a recent book, *An Agricultural Testament,* by Sir Albert Howard, C.I.E., M.A., formerly Director of the Institute of Plant Industry, Indore, and Agricultural Advisor in Central India and Rajputana. Sir Albert's discussion of the agricultural practices of the Orient caused me to recall that multiple (or disseminated) sclerosis is practically unknown in Japan and China (Miura, Pfister) ; that there is some question whether one sees genuine pernicious anemia with its severe neurological complications in Northern China; that, although syphilis is as frequent as the common cold in Korea, tabes was not once diagnosed by Wilson, who practiced there thirty years; that there is a remarkable scarcity in China of arteriosclerosis, Gaucher's disease, kidney stones, gallstones and perhaps even thrombophlebitis. (Snapper)

Is it not possible that Nature has presented us with a great many more pertinent facts in the geographic distribution of disease and health? The reasons for the presence and absence of certain diseases among the population of various parts of the world present a complicated and involved question. These natural experiments that are being made all over the world, due to a multiplicity of local circumstances, customs and habits, or changes forced on a people by war or poverty, make available a wealth of material for study and investigation.

What are some of the natural experiments that present material which we may use as indices of health and disease found here and there? And what are the agricultural practices of these respective locations, which may affect the quality of their food?

Heard states: "Dental caries is rare in the town of Here-

ford and the County of Deaf Smith, Texas. . . . . After twenty-eight years of interrogating my patients, together with my experience and observation, I am of the opinion that this phenomenon is due to our soil's richness in minerals and vitamins. The growing of plant foods has depleted the soil in most areas of the world of essential mineral elements; and our system of fertilization has failed to restore these elements in adequate quantities." He also comments: "Both physically and mentally this area furnishes superior zoological specimens."

McCarrison records an observation: "My own experience provides an example of a race, unsurpassed in perfection of physique and in freedom from disease in general. . . . I refer to the people of the State of Hunza, situated in the extreme northernmost point of India. Amongst these people the span of life is extraordinarily long; and such service as I was able to render them during some seven years spent in their midst was confined chiefly to the treatment of accidental lesions, the removal of senile cataracts, plastic operations for granular eyelids, or the treatment of maladies wholly unconnected with food supply. Appendicitis, so common in Europe, was unknown. . . . It becomes obvious that the enforced restriction to the unsophisticated foodstuffs of nature is compatible with long life, continued vigor and perfect physique."

McCarrison carried out in India some experiments on rats. He mentions first the many different native races of which the population, 350 million, is composed. After describing the experiments he concluded: "What I found in this experiment was that when young growing rats of healthy stock were fed on diets similar to those of people whose physique was good, the physique and health of the rats were good; when they were fed on diets similar to those of people whose physique was bad, the physique and health of the rats were bad; and when they were fed on diets similar to those of people whose physique was middling, the physique and health of the rats were middling."

I would like to mention two observations during World War No. 1—first, Hindhede states: "In Denmark the people received a sufficiency of potatoes, whole-rye bread (containing wheat bran and 24 per cent of barley-meal), barley porridge, grains, milk, abundance of green vegetables and some butter. In consequence of this enforced alteration in the dietetic habits of the Danish people, the death rate dropped as much as 34 per cent, being as low as 10.4 per cent when the regimen had been in force for one year." Hindhede concludes that "the principal cause of death lies in food and drink." The second observation was by Demoor and Slosse, who noted: "Despite the food restrictions imposed upon the people of Belgium during the late war, the infant mortality and infantile diarrhea have decreased greatly;" a circumstance, according to this article, which was "due to organized propaganda encouraging mothers to nurse their infants and to the establishment of national canteens which provided prospective mothers, from the fifth month of pregnancy onward, with eggs, milk, meat, and vegetables."

The Local Medical and Panel Committee of Cheshire, England, representing 600 doctors, reviewed their 25-years experiences, stating: "There has been a fall in fatalities and this was all the more noticeable in view of the rise in sickness. . . . This illness results from a lifetime of wrong nutrition." They point to the high incidence of bad teeth among English children in the British Isles, but this condition does not exist among their cousins on Tristan da Cunha; also, rickets is still common in England, while in Holland it is relatively rare; there butter, milk and cheese are plentiful. They further point to nutritional anemia and defective diet constipation." They go on to say: "It is far from the purpose of this paper to advocate a particular diet." They remark on the health and the diet of the Eskimos and the Hunzans and the English on Tristan da Cunha and say: "There is some principle or quality in these diets which is absent from, or deficient in, the food of our people today . . . to decry some factors common to all of these diets is

difficult, and an attempt to do so may be misleading since our knowledge of what those factors are is still far from complete; but this at least may be said—that the food is, for the most part, fresh from its source, little altered by preparation, and complete; and that, in the case of those based on agriculture, the natural cycle:

Animal and)		**(Animal —)**	
Vegetable)	**— Soil — Plant — Food**	**(**	**Man**
Waste)		**(————)**	

is complete: no chemicals or substitution stage intervenes."

This committee refers to the work of Sir Albert Howard, stating: "He has shown that the ancient Chinese method of returning to the soil, after treatment, the whole of animal and vegetable refuse which is produced in the activities of a community, results in the health and productivity of crops and of the animals and men who feed thereon."

In this article it is indicated, not only how bad teeth, rickets, anemia and constipation may be helped, but the observations of the family doctors revealed that the nutrition of expectant mothers was closely supervised in a Cheshire village, the diet being raw milk, butter, Cheshire cheese, oatmeal, eggs, broth, salad in abundance, green leaf vegetables, liver and fish weekly, fruit in abundance, meat and whole-meal bread made of two parts of locally grown wheat and one part of raw wheat-germ, the bread being baked within 36 hours after the milling of the flour. It was noted that mothers were usually able to feed their infants. The nursing mother's food continued as in pregnancy. The children were described as splendid, with perfect sets of teeth common; pulmonary diseases were almost unknown; they slept well, and one of their most striking features was their happy personality. The opinion was expressed: "The human material was entirely unselected, the food was not specially grown but that in spite of these imperfections, the practical application of McCarrison's work should yield recognizable results shows that in a single generation improvement of the race can be achieved."

Sir Albert Howard points out: "Soil fertility is the condition which results from the operation of nature's round, from the orderly revolution of the wheel of life, from the adoption and faithful execution of the first principle of agriculture—there must always be a perfect balance between the processes of growth and the processes of decay. The consequences of this condition are a living soil, abundant crops of good quality, and livestock which possess the bloom of health. The key to a fertile soil and a prosperous agriculture is humus. Humus in the soil affects the plant directly by means of a middle man—fungus—producing the mycorrhizal relationship. Nature has provided an interesting piece of living machinery for joining up fertile soil with the plant."

Does it follow that the agricultural practices of the Orient account for the seeming absence of some of the degenerative diseases that we are more prone to have in America and Europe? Is the produce of our farmers using artificial fertilizer lacking in quality because the chemicals are not sufficient to give food quality? Is there a relationship between food produced on a soil rich in fungus and the absence of susceptibility to diseases of those who live on this food?

In agricultural literature the importance of these fungi in promoting growth and aiding nutrition has been emphasized. Dubois (Rockefeller Foundation) cultured from the soil his gramicidin-producing fungus. Would there be anywhere near as much need for gramicidin and penicillin if our food were derived from a humus-rich soil prolific in its fungus growth? Has the Occidental agricultural practice of using commercial fertilizers been inadequate and destroyed the bacteria and fungus in the soil and, in turn, given us an inferior produce that has reduced our natural immunity to infections?

This paper is presented as a preliminary discussion, and the thoughts are merely suggestive. The scientific investigation of the sources of food supply in this country and the

after effect upon health and disease, especially, as we have pointed out, degenerative diseases, has not gone far enough to justify definite conclusions. The observations are certainly indicative of possible fact, and stimulate us in our studies of this *x* quality factor in food. The studies and results of experiments already made by distinguished scientists, some of which have been mentioned, strongly indicate that efforts toward the prevention of diseases, especially of deficiency diseases and diseases of a degenerative character, and the consequent improvement of the health and happiness of the human race, demand a more thorough study of the sources of food supply, the methods of production, and the soils from which foods are produced. Nutrition is not a question of quantity only but of quality also.

CHAPTER XV

Soil Fertility and Its Health Implications

WILLIAM A. ALBRECHT*

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It is scarcely necessary to say that dentists have more than a passing interest in soil fertility, since they know that strong, healthy teeth contain a high concentration of calcium and phosphorus—nutrient elements that head the list of minerals drawn from the soil for sustenance of plant and animal life. Of the total gross weight of the teeth as part of the human skeleton, one-fourth is calcium and one-eight is phosphorus. Of the tooth enamel, one-third is calcium and one-sixth is phosphorus.

As cardinal requisites of a fertile soil, calcium and phosphorus in the form of limestone and superphosphate are the two foremost fertilizers or soil treatments used by well-informed farmers. Too frequently, however, these treatments are regarded merely as a means of obtaining greater tonnage or more bushels of crops per acre.

But when shortages in bulk of foods confront us, it is all the more essential that we improve the quality of that bulk. It is the soil on which, after all, the health qualities of foods depend. When teeth are calling for much calcium and phosphorus, defective teeth are not far removed from crops that are calling in vain on the soil that is deficient in these two mineral constituents of man's skeleton and teeth.

Read before the Mid-Continent Dental Meeting, St. Louis, Mo., Nov. 2, 1944.

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The Dental Profession Has a Real Stake in Soil Fertility

In addition to calcium and phosphorus, there are about ten more growth-promoting, body-building nutrients on the list of fertility elements that soils must provide for vigorous, healthy bodies and sound teeth. Shortages in any one of these elements needed in body construction, or in catalytic service in body or plant growth, will reappear in the human family as health deficiencies. We cannot therefore afford to tolerate shortages in the soil's store of these truly "grow" foods.

Besides these dozen so-called "grow" foods, or elements coming from the soil, every growing body and every growing plant must have what can conveniently be called energy providers or "go" foods. The elements constructing such compounds are, in the main, carbon, hydrogen, and oxygen. They come from the air and water. Nitrogen also comes from that source, so that as much as 95 per cent of plant mass or animal body weight is combustible. It serves in provision of energy and in giving bulk and weight.

Photosynthesis and Biosynthesis

Because the recognition of mass is a simple mental impression, the concept of bulk is always easily and quickly caught. So commonly are crops measured by weight that we are just now coming to realize that the "growth" quality, or the nutritional value of herbages is not the same as the tonnage value. A bushel of corn is always 56 pounds, but one bushel may be nourishment while the other is not, as judged by livestock growth. Plants attain mass of growth through the service of sunshine as it makes carbohydrates through use of the sun's energy in the chlorophylous leaves. This process of chemical synthesis of carbon, hydrogen, and oxygen into carbonaceous products gives tonnage, but surely this photosynthetic behavior does not guarantee animal or human nourishment when it results in trunks of trees consisting only of just so much woodiness. Sunshine, fresh air, and water—processed through the suprasoil activities by plants—may be responsible for 95 per cent of plant bulk, yet contribute nothing to nourishment of higher life forms.

Nutritive values of herbages result from the synthesis of compounds within the growing plants, as for example, those that give rise to the seed and will feed our animals. These values are dependent on the calcium, phosphorus, magnesium, etc., that come from the soil. Animal life finds plenty of bulk for consumption. Recall hastily, if you will, the many plants which animals refuse to eat, or the many we call weeds. Nutritional deficiencies result from the failure of that vegetative bulk to have within itself the products of synthetic activities by the plant quite aside from products directly from photosynthesis. We need to appreciate what may well be called the "biosynthesis" or the synthesis by the life of the plant that depends not on air and water, but on the delivery by the soil of its complete list of soil fertility elements to be constructed by the plant into what is truly food substance.

In considering plants as phenomena of growth, we may well think of them first as a photosynthetic performance. This builds the woody frame of the plant, uses only limited amounts of soil fertility, mainly potassium, as catalytic agents, to set up the factory and provide its fuel supply. In the second place, plants are a biosynthetic performance, into which the soil fertility enters more directly to have its phosphorus, sulfur, nitrogen, etc., synthesized into proteins, vitamins, and other compounds truly valuable for body construction rather than for fuel only. It is the soil fertility much more than the sunshine and fresh air that determines how well the plant really gives us nourishment. It is this biosynthesis and not the photosynthesis whereby soil fertility takes on its significant implication in your health, in my health, in your teeth and in my teeth.

Virgin Plant Growth Concentrated the Soil Fertility in the Surface Soils for Help to Man

That the entire land surface of the earth cannot be generous in its provisioning of human and animal life becomes almost axiomatic when it is known that the soil must deliver about a dozen chemical elements. Soils constructed

under good physical conditions, and stocked with such a large number of nutrient elements, must of necessity be the exception rather than the rule. Plant life in virgin condition has been sending its roots down and searching through large volumes of soil to collect and assemble in the surface layer as organic matter or humus, these many elements needed. Hundreds of years of virgin condition have kept within the plant life, as a cycle of growth, death, decay, and re-use, these nutrient mineral elements from the soil. It is this feature that makes surface soil so valuable while subsoil is so unproductive.

Soil Construction and Soil Destruction

Naturally, soils vary widely as to their fertility since soils are temporary rest stops of rock en route to the sea and to solution. In lower rainfall areas the soil is finely ground rock. It is mainly mineral, with little clay and little water for plant growth. The plants grown there are mineral-rich, however. More rainfall gives more clay, more plant growth, more organic matter to decay. It also leaves a rock reserve to supply the clay as it gives up its nutrients to the plants. In central United States with its prairie areas, we have soils now in the stage of maximum of construction of clay that is in balance, or equilibrium, with a generous reserve of rich minerals to maintain productivity. With no more than 30 inches of rainfall along approximately the 97th meridian of the United States, we have the Midlands, where the animals raise themselves and human health is good as indicated by the fact that seven out of ten draftees pass inspection in Colorado while only three out of ten do so in a southern state.

With higher annual rainfalls and higher temperatures, the rocks are so highly weathered and the clay is so changed that it represents soil destruction. This is the prevailing condition in eastern and southeastern states. In terms of this degree of soil development we can see the basic principles of nutritional troubles in the southern states, of limit-

ed populations in the tropics, of population concentrations into limited areas of the temperate zones, of customs whereby aborigines survive while the white man fails utterly, and numerous seemingly uncanny situations where the influence of soil fertility upon the human species is not yet appreciated.

Crop Juggling Disregards Soil Fertility

An ecological survey with tabulations of plant species is not needed to locate the forests in the northern regions, in the tropics, and in eastern and southeastern United States, nor to locate the prairies in central United States, and the barrens in the West, excluding the western coast. Underlying this seeming agreement of greater vegetative production in forests with higher rainfall, and vice versa, there is the soil fertility. We have not been connecting the different crops, their tonnage production per acre, and their chemical composition in terms of nutritive value for animals with the soil fertility. That the scantily growing buffalo grass of western Kansas was more nutritious because of more fertile soils than the lush bluestem of eastern Kansas on the less fertile, more leached soils was recognized by the buffalo. This brawny beast stayed on his scant grazing because it meant growth, muscular and bony body, and good reproduction. There was no natural obstruction to prevent his coming eastward, had he desired to move to get more bulk per acre.

More protein in the wheat as we move westward across Kansas follows the same course, with the less leached soils in central and western Kansas giving high protein in wheat. But in place of recognizing soil fertility as the controlling factor, we have been ascribing the difference to rainfall or to plant pedigrees. Plant breeding has been credited with wonders when we think of hybrid corn. But to date no geneticist's creation has yet come forward that can tolerate starvation or the lack of soil fertility.

Crops have been introduced, moved from place to place

and pushed to the very fringes of starvation, while we have kept our attention fixed on the pedigree in place of the plant's nutrition. During this crop juggling, the chemical composition of the plant has shifted. Photosynthesis has come into prominence while biosynthesis has almost disappeared. The crop has retained its service in giving energy values but lost much of its service as a growth food and carrier of soil minerals elaborated into organic complexes of nutritive value. We have gone from proteinaceousness and high mineral contents in plants grown on soils under construction through lower rainfall to carbonaceousness and mineral deficiencies in plants grown on soils under destruction through higher rainfalls. Nutrition at the same time has rescended from a level of bone-building, brawn-making, and fecund reproduction to hydration, obesity, fattening performances and other excesses of weights with weakened bones and flabby muscles, to say nothing of carious teeth, alveolar bone disintegration, and other oral troubles.

Declining Soil Fertility Brings the 'Sweet Tooth'

Declining soil fertility has been pushing out of the agricultural program those crops drawing heavily on the soil fertility, and naturally of high nutritive values. As such crops failed to produce tonnage, we have sought other crops maintaining the tonnage production per acre but failing to provide the nutritive equivalents per acre and the nutritive concentration or food value per pound. Carbonaceousness, consequently, has come into prominence, while proteinaceousness and high mineral contents have dwindled.

Declining soil fertility has been provoking the shift to feeding our animals on fattening feeds, and our own shift to soft wheats, and to starchy and saccharine elements in our diet. Our "sweet tooth" in a dietary sense has become a carious tooth in a dental sense as a result of the unobserved and unappreciated exploitation of the soil fertility, and shift in dominant plant composition.

Failing Skeletons Go With Failing Teeth

When the simplest expression of the chemical composition of bones and teeth puts these two together in the same category with their ash containing 894.5 parts of calcium phosphate per thousand parts, these two soil-borne elements, calcium and phosphorus, are lifted into prominence. This dare not, however, crowd out the 15.7 parts of magnesium phosphate, the calcium fluoride, the chloride and the carbonate of calcium as 3.5, 2.3, and 101.8 parts, respectively, and the 1.0 lone part of iron oxide. That this complexity in chemical composition of the teeth is no mere accident is well worth considering, and that it is a specific combination which makes for sound teeth only by good metabolism to maintain its specificity is also worthy of serious consideration. Shifts in the fluorine content, that makes up less than .013 per cent of the enamel of the teeth, are known for the troubles they cause. Can we not then appreciate the inevitable incidence of tooth and skeletal troubles when the supplies of calcium and phosphorus in the foods fluctuate widely in amounts and in chemical combinations ingested, while we keep our eyes fixed on food bulk only?

Animal studies are pointing out the widely variable thickness, size, strength, and other properties of bones of animals according as they are fed different hays, the same hays from different soils, or the same hays from the same soil given different soil treatments, such as limestone and phosphate. Hidden away as it is within the animal's body, the skeletal structure may be undergoing drastic shortages in calcium and phosphorus that are readily passed over without concern. Surely the jaws carrying the teeth cannot escape registering these same irregularities taking place in the other skeletal parts.

To the Drugstore for Cure Rather Than to the Soil for Prevention

Even though the practice of salting domestic animals has been with us for scarcely a century and a half, we have taken readily to the belief that the deficiency in any essential

element in the diet can be met by its ingestion as a simple chemical salt in its ionic and molecular forms. With sodium and chlorine, both of which are monovalent and extremely soluble, accepted in the common salt form by domestic animals and searched out in the "salt lick" by wild animals, there may be serious error in concluding that deficiencies of calcium phosphates in the diet may be met by ingesting the salts of tricalcium phosphate or calcium and phosphorus in one or the other acid phosphate forms. Calcium is a divalent and phosphorus is a pentavalent ion. The two are closely associated or combined chemically wherever phosphorus is found in Nature. They serve such important roles in plant life where sodium and chlorine are not considered essential that it should seem fallacious even to postulate that calcium and phosphorus as salts can serve as effectively in both processes as when they are part of the compounds elaborated by plant synthesis.

The eating habits of the animals themselves offer suggestions. The eating of bones by cattle is not common. It occurs only after the animal arrives at certain stages of emaciation resulting from feeds deficient in phosphorus. This is quite different from their behavior relative to sodium chloride of which the consumption does not suggest itself as an act of desperation.

The behavior of rachitic bones suggests that the advent of calcium and phosphorus into the digestion via the plant as it has taken them from the soil is more effective when these come through this route whereby it is synthesized as organo-complexes rather than simple mineral salts. When a rachitic bone is cut longitudinally and immersed in ionic calcium phosphate solutions, the calcium and phosphorus are not readily deposited in the unmineralized bone parts. However, when such a bone is placed in a solution of calcium hexose monophosphate or calcium glycerophosphate, it absorbs the calcium and phosphates, to deposit them as minerals in the zone of the rachitic bone prepared for calcification. Such behaviors suggest that the organo-calcium phos-

phate may be a much more efficient means of introducing these bone-building ions into the skeleton and teeth than are calcium and phosphorus ingested simply as ionic salts.

Yeasts, as fermenters of sugars, require phosphates in order that this reaction giving off carbon dioxide may proceed. The phosphate acts seemingly as a catalyst. It enters into combination in one step in the process, but is not a part of the product. Thus, the phosphate is not serving in construction of the body of the yeast cell, or as a part of it. Rather it is serving in the chemical reaction that provides the energy for the life of the yeast. Calcium phosphate, as it serves in the energy reactions or metabolism of higher life, is still not a known phase of its behaviors in nutrition.

Here is the suggestion that the calcium and phosphate ions do not use the plant merely to hitchhike from the soil to the stomach of the animals. Rather it suggests that while these nutrient elements are helping in the biosynthetic performances within the plant, they are functioning in its metabolic performances and putting themselves into some unique organic combination through which they can move into the construction of the bones and teeth so much more effectively.

Then, too, when calcium gluconate, another calcium organo-complex injected into the blood stream, is an effective cure for milk fever, it emphasizes the plausibility of the belief that calcium and phosphorus in the blood stream in non-dialyzable or colloidal form may be playing far more essential roles than we have been inclined to appreciate while focusing attention on them mainly in their ionic behaviors. Much about the physiologic activities of these two nutrient elements remains to be learned, but surely there are strong suggestions that as they play these roles we can aid their functions more from the soil forward by using them as fertilizers in the plants and thus for preventions, than from the drugstore backward and thereby as cures for nutritional troubles by which havoc has already been wrecked in the body.

Other Aspects of Soil Fertility

Your attention has been focused specifically on but two nutrient elements of the dozen (possibly more) essential ones coming from the soil for human sustenance. If recognition of the deficiencies of these two in the soil has led us to understand the irregularities in plant physiology of the food crops we eat, and deficiencies in our teeth, our skeleton, and our own body physiology as all these provoke bad health, we need to prepare ourselves for more troubles arising as the remaining nutrient elements are being drawn from the soil. Potassium has long been registering its shortages for crops, but fortunately is so bountifully supplied by food plants that our bodies excrete rather than hoard it. Magnesium, however, which is the next on the list, cannot be viewed with so little concern. Shortages of this element in the soil are already impending. Heavy limings with calcium limestone only and soil conservation activities without attention to magnesium may throw a panic into body physiology and sound teeth. Elements no more plentiful than fluorine required in drinking water by quantities as low as one part per million and coming in milk in from 5 to 25 parts per ten million are only beginnings in our thinking about several elements to which quantitative attention for health's sake has not been directed. We are soon to face the health problem linked with all the dozen (possibly more) nutrient elements contributed by the soil as we have just begun to connect rickets, teeth decay, and other troubles with calcium and phosphorus. With such a large list to be compounded into medicine by the drugstore, surely in desperation we ought to turn away from medicinal concoctions for cure and learn to put fertility into the soil so as to give help to Nature to nourish us for disease prevention instead.

Public Health Calls for Conservation of Soil Fertility

The importance of the soil as the basis of our nutrition has not yet been appreciated. For too many of us, food comes only from the grocery and the meat market in paper bags, fancy cartons, glass bottles, and tin cans. We are measuring

it only by weight or cost per plate. Milk is still sold by the gallon and by its fuel value in terms of fat content, when milk may be so deficient as to give rickets even to the calf taking it, uninjured by aeration and pasteurization, directly from the mother cow. Milk, which is closely connected with reproduction, is lowered in its quality even as the function of reproduction, itself, is impaired by nutritional deficiencies resulting from neglect of the soil. Reproductive cells, both as egg cells in the female or sperm cells in the male, are a physiologic output by the body for reproduction —just as milk is food for service to the young in the same reproductive process. Egg cells and sperm cells defective because of deficient soil fertility and malnutrition are just as possible physiologically as is defective milk.

To the observant dentist, teeth and the mouth as a whole reflect the nutritional plane of his patient and thereby reveal not only the irregularities in the quality of his food, but should point much farther back to the plane of soil fertility in the region where the patient's food was grown. With that extension of the view of your mind's eye as you look into the mouths of children, we trust you will catch some suggestion that you in an office on the paved street have some share in conservation of the soil that is owned and managed by the man of the country who may seemingly be miring in the mud. That mud is becoming more precious for health's sake.

The following is from Dr. Wm. A. Albrecht, Chairman, Department of Soils, College of Agriculture, University of Missouri:

Man is going to be controlled in his behavior by the extent to which there is mobilized in the soil about a dozen simple chemical elements commonly found in mineral and rock combinations. Consequently, we want to see man in his behavior in that ecological picture with all other life forms wherein the fertility of the soil is at the controls. Those who are in the limestone industry are dealing with one of

the ten elements—probably two if you are dealing with dolomitic limestone—that is at the control of agriculture, at the control of food, and at the control of all life, including man.

We think of food in terms of bulk, weight, volume. We seldom think of it in terms of its quality as nourishment. In the making of food, we have two objectives as to its quality; first, it should give us power and energy; but before we can use that power and energy we must construct the body, and food must meet the second objective, namely provide growth substances.

Reduced to its chemical simplicity, the body is about 96 per cent of these four elements that find their origin in air and water. It is about 5 per cent of a list of 10 or more elements that find their origin in the soil. We have been keeping our eyes keyed on bulk. We have been keeping our eyes fixed on those four substances, namely carbon, hydrogen, oxygen, nitrogen, that are liquid or gaseous in form and that flow and move freely. Therefore, they do not represent much of a struggle for us to get them. We have not given enough attention to the other elements that are fixed in their position in the soil and to which the plant or the animal must go for their service.

We have literally been in a blind alley for a number of years on this matter of liming, we have been thinking that the lime is serving a great function in fighting soil acidity. That is a fight that ought now be over. It should have been over a long time ago. Peace along these lines ought to be declared. We are no longer liming for the purpose of fighting soil acidity. We are now liming in order to introduce calcium and magnesium as fertility elements to be mobilized for better plant and animal production.

NOTE: Dr. Albrecht is now in Paris, France, teaching the French the Science of Soil and Health. He was hired by France for this purpose.

CHAPTER XVI

Producing More Beef From Phosphorus-Deficient Ranges

Here's the story, as reviewed in U. S. Department of Agriculture Research Achievement Sheet No. 7A, recently issued:

Research based on observations of a government scientist assigned to South Africa nearly 15 years ago, on the value of supplemental feeding of phosphorus to beef cattle grazing on soils deficient in that element, has developed information worth millions of dollars to the American livestock industry.

"In the Gulf Coast region and other parts of the South, where the soil and vegetation are deficient in phosphorus, the feeding of small amounts of this mineral to cattle is now known to increase beef production. Benefits include larger and more regular calf crops and more rapid and economical gains."

The statement says the Department's research leading to this knowledge dates back to 1931, when William H. Black of the Bureau of Animal Industry studied the beef-cattle industry in the Union of South Africa, where much of the land is deficient in phosphorus. Mr. Black, now senior animal husbandman of the Bureau at Beltsville, Md., observed that cattle in such areas often received a supplemental feeding of bone meal, which supplies phosphorus.

"He noted the high fertility of the cows, as indicated by the large number of calves," according to the government's report. "The cattle were in good flesh, with evidence of good bone development. He also noted that the South African veld resembled range areas in Texas, Arizona, and New Mexico."

Tests Conducted At State Experiment Stations and on King Ranch

The statement continues: "On his return to the United States, Black made plans to determine whether the feeding of phosphorus or other minerals would be beneficial here under similar conditions. Work conducted by the Texas, New Mexico, and other state experiment stations, before or about that time, supported the likelihood of such benefits. In 1937 the Bureau of Animal Industry began a study of the problem in cooperation with the Texas station and the King Ranch of that state. Analysis of forage samples as well as blood samples from cattle of the area showed phosphorus deficiencies, but supplies of other important minerals were apparently adequate. In experiments to determine what benefits might be derived from a phosphorus supplement, four groups of young cows were fed on the range. One group received no supplement. The other three received, respectively, disodium phosphate, bone meal, and bone meal with small quantities of other minerals, by hand-dosing six times a week. Most of them received 6.5 grams of phosphorus per head daily, but lactating cows got about twice as much."

CHAPTER XVII

Biological Assays of Soil Fertility[1]

WM. A. ALBRECHT and G. E. SMITH[2]
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The values of soil treatments, such as manure, phosphates, limestone, and other fertilizers, have usually been measured in terms of the increased yield of crops. Whenever the cost of the treatment is less than the sale value of the increased bulk, whether grain or forage, then the soil treatment is usually regarded as an acceptable farm practice. This assumption has been the basis of much of the experimental work with fertilizers and of many recommendations as to fertilizer use. Farmers, however, have been obliged to discount it for risks of weather, pests, crop diseases and prices. Hence with the commonly low and fluctuating monetary values from direct sale of field products, the margin of profit from treatments on many Missouri soils has frequently been small. This has not encouraged the additions of fertility to the soil as extensively as an approach to soil maintenance requires.

There has been only a little upward trend in fertilizer use despite the belief that fertilizer consumption in Missouri, for example, could be much increased with profitable results. In 1940, one and one-third million tons of limestone were used in the state, but even this amount is not sufficient to replace even the annual leaching loss of lime from the soil. With the decline of soil fertility recognized as the main cause of economic distress by only the few soil chemists, there is a serious need to translate soil fertility from a for-

[1]Contribution from the Department of Soils, Missouri Agricultural Experiment Station, Columbia, Mo. Journal Series. No. 788.

[2]Professor of Soils and Instructor in Soils, respectively.

eign language of chemical formulae and tonnage increase per acre, to one that speaks in terms of better animal growth and greater provision of more nourishing human food as antidotes for dangerous deficiency diseases that are ravaging and deforming both animal and human bodies.

Animal assays, or animal interpretations, of the value of soil treatments might encourage wider use of them for soil fertility maintenance and improvement.

Trend Toward Pastoral Farming Without Soil Treatment Invites Disaster

In many instances farmers on thin, eroded soil have not believed that the increased yields from applications of fertilizers, including lime, particularly with weather and insect hazards, have been sufficient to warrant their use even on cash crops. This says nothing of their use on the pasture and hay crops of which the acre yields remain unmeasured and are not evaluated so commonly in immediate monetary returns. Since there is a rapidly gaining movement toward more livestock or toward the pastoral system of farming, this indifferent attitude toward soil maintenance is distressing. It will lead toward poorer yields, less profit, greater soil depletion and more devastating soil erosion. A continuation of this trend must result in a lowered economic status of farmers. It will make any future amelioration program all the more difficult. Any means, or any program, therefore, that may be used to demonstrate the feasibility of soil treatment in this state at this time is highly desirable.

It has long been known that the chemical composition of any single forage or hay crop may be influenced by the degree of maturity or time of cutting, and by the kind of soil on which it is grown. When soil treatments are used, the flora of a pasture sward may be modified so as to bring in plants of higher feeding value for animals. Research in pasture improvement shows that the concentrations of protein, minerals and carbohydrates in plants are changed by the application of different soil treatments. Such changes

indicate that the use of fertilizers on farm crops may have effects beyond recognition as mere increase in weight of crops produced, and are effects that have therefore not been widely recognized. Perhaps, Crampton and Finlayson,[3] more than anyone else, have pointed to the value of bioassays of soil treatments.

From indications and suggestions by chemical studies of the plant behavior through refined control of nutrients offered on colloidal clay growth media, it is believed that there are important benefits from fertility additions to soils that cannot be measured in terms of bulk increase in yield. The hypothesis is ventured that hidden benefits from soil treatments can be demonstrated through assays with smaller animals. For detection of these benefits, experimental attention may well go toward some new methods for evaluating soil treatments in terms of their biological assays.

Benefits Other Than Increased Yields Come From Soil Treatments

Soil treatments show effects on the chemical composition of numerous crops grown in experimental trials in the field. Lespedeza, for example, has been consistent in its changes in composition as a response to various soil treatments. Table 1, giving the analyses of this crop grown with different soil treatments, is typical of these.

These data show that the soil treatments demonstrated effects other than merely that of increasing the forage yields. When the percentage of protein and the increased forage yield as a result of the soil treatment of lime plus phosphate are considered, it is not beyond the imagination to consider that this type of forage should have some unlisted improvements and a greater feed value per unit of forage weight than would the forage receiving only phosphate. The data point to greater differences in the feed value per acre than would be indicated by a yield increase of only 594 pounds. The increases in delivery of phosphorus and calcium per acre are also items that must not be overlooked. Their

significance, however, would seem small in comparison with the protein which gave differences both in concentration and in total yields. If the addition of lime will increase the protein content within the legume forages, as it has in the case of this lespedeza, it is not unreasonable to suppose that organic compounds other than proteins, not commonly determined analytically but yet highly essential in animal growth, may also be favorably influenced.

Animals As An Aid in Determining Effects of Soil on Forage Values

Trials with Sheep, 1939-40

A preliminary experiment with sheep was conducted to ascertain some possible effects of lime on lespedeza as it gives values other than increased tonnage, increased protein, and increased minerals as commonly measured by chemical determinations.

Lespedeza hay was taken from an area which includes numerous phosphates comparably applied to wheat and barley on both limed and unlimed soil and grown to this legume. Before the baled hays were in shelter a heavy rain damaged them severely. The damage was greater to the hay from the limed land, probably because of its higher protein content, so that when the better portions were saved the hay from the unlimed soil appeared to be of better quality. Because of much loss of hay, the supply carried the experiment only for 45 days, and was supplemented by other hay from two adjacent farms of similar soil. The analyses of these

Table 1.—Influence of limestone and phosphate on the composition and yields of lespedeza, Columbia, Mo., 1938.

Soil treatment	Yield, lbs. per acre	N, %	P, %	Ca, %	Delivery, lbs. per acre Protein	P	Ca
None	762	1.79	0.19	0.93	73.9	1.44	7.1
Phosphate	800	1.81	0.20	0.98	79.2	1.78	8.8
Phosphate and lime	1,394	2.09	0.19	0.94	182.0	2.53	13.2

[a]Crampton, E. W. and Finlayson, D. A. The effect of fertilization on the nutritive value of pasture grasses. Emp. Jour. Exp. Agr., 3:331-345. 1935.

supplementary hays, as shown in Table 2, agreed well with those of the initial forage.

Experimental sheep were started on feed on September 28, 1939. They were given all the hay they would eat plus a daily supplement of ¼ pound of oats and ¼ pound of wheat bran per head per day. Table 2 gives the analyses of the hay. Table 3 gives the hay consumption, the gains by the lambs, and other details, during the 108-day feeding period from September 28, 1939, to January 13, 1940.

Nutritive Improvement Greater Than Changes in Chemical Composition as Commonly Measured

The performance by the sheep as related to the composition of the hay shows clearly that the effectiveness in producing animal gains by the elements, or compounds, contained in the hay was much greater than was the increase in concentrations in the chemical composition of the forage because of the soil treatment. The analyses of the hay reveal an increase in protein concentration from 10.7% for the phosphated plots to 13.7% for lime addition with the phosphate. This was an improvement in protein composition of nearly 30%. When combined with better tonnage yield it amounted to 128 pounds more protein per acre.

The gains made by the lambs were fairly uniform per pen throughout the duration of the experiment, but the figures show that those fed the phosphated hay gained 0.073 pound per day, while those fed the phosphated and limed hay

Table 2.—Analyses and yields of lespedeza hay from Putnam silt loam with different soil treatments.

Soil treatment and location	Yields lbs. per acre		N, %	Protein, %	Ca, %	P, %
	Hay	Protein				
Phosphate (South Farm)	2,190	235.4	1.72	10.7	0.866	0.170
Phosphate and lime (South Farm)	2,652	363.3	2.20	13.7	0.944	0.175
No lime (South Farm)	....	....	1.38	8.7	0.860	0.150
Lime (Bowling Farm)	....	....	2.01	12.5	0.996	0.170

Table 3.—Lespedeza hay consumption as related to gains by lambs, 1939-40.*

	Hay from untreated or phosphate treated soil	Hay from soil treated with phosphate and lime or lime only
Sheep days†	1,382	1,437
Hay offered per pen, lbs.	3,864	3,987
Waste hay recovered, lbs.	882	906
Hay consumed, lbs.	2,982	3,081
Gain per head per day, lbs.	0.0735	0.1106
Hay consumed per head per day, lbs.	2.14	2.14
Hay per pound gain, lbs.	29.2	19.4
Protein per pound of gain, lbs.‡	2.13	2.66
Gain per pound calcium, lbs.‡	3.95	5.66
Gain per pound phosphorus, lbs.‡	20.1	29.5
Gain per acre lespedeza, lbs.	74.9	136.5

*Feeding period 108 days, Sept. 29, 1939, to Jan. 13, 1940.

†Number of sheep times the days on feed. Some lambs were removed before the end of the period.

‡When the total gain is calculated as though produced by the hay only and no value given the supplement. Supplement consisted of ½ pound daily of mixture of equal parts of oats and wheat bran. Lambs weighed 70 pounds each as mean per pen at the outset.

gained 0.110 pound per day. This represented an improvement in animal growth of slightly more than 50% from a soil treatment which improved the chemical composition of the hay by only 30%.

Since the two pens of sheep consumed exactly the same amount of hay per head per day, namely, 2.1 pounds, it appears that the sheep were consuming the maximum and that the gain beyond the equivalents in improvement in chemical composition must have been due to some variations in the hays not detected by the common methods of feed analyses. Had no supplement been fed, this difference might even have been greater since the supplement probably covered some of the nutrient deficiencies in the hay grown on soil given phosphate but no limestone. The animal assay revealed values beyond those commonly assigned when measured by chemical assay.

According to the data in Table 3, 29.2 pounds of the hay from the phosphated plots were required for each pound of

animal gain. Only 19.4 pounds of the hay from the soil with the treatment of lime and phosphate were necessary for the same gain. From such results it not only appears that the hays differ in feeding value, but it also suggests forcefully that the nutritive ingredients in the hays are significantly different. If the supplement, which was a constant for both pens, is disregarded, then from the phosphated hay it required 3.13 pounds of protein to produce a pound of gain, while in the hay from the phosphated and limed soil a pound of gain was produced from only 2.66 pounds of protein. This suggests a 17% greater efficiency in the use of the protein in the better hay.

When the calcium in the hay is considered, while that in the supplement is disregarded, then a pound of this element consumed in the phosphated hay produced only 3.95 pounds of animal gain, while the same quantity of calcium in the hay from soil treated with both phosphate and lime produced 5.66 pounds of gain. This greater efficiency in the calcium delivered to the animal amounted to more than 43% when reflected as body gain. With similar consideration of the phosphorus, the hay receiving only phosphate as a soil treatment produced 20.1 pounds of animal gain for each pound of phosphorus supplied in the hay, while the hay from the limed soil produced 29.5 pounds of gain for each pound of phosphorus consumed. Here again is a difference as large as 47%, or a much greater efficiency in the conversion of crude soil fertility nutrients into high-priced, readily salable animal products.

Economy Per Acre Widely Different

Converting these differences to the farm-acre basis, an acre of the lespedeza hay grown on phosphated soil would have produced 74.9 pounds of lamb gain, while an acre of the soil given the fertility addition of both lime and phosphate would have produced 136.5 pounds. This final difference in animal increase per acre is the summation of the significance of soil treatments. Through the simple addition of limestone to phosphate as a soil treatment there was an

increase of 21% in the yields of hay, an increase of 30% in the protein content of the forage, an increase of 50% in the animal gain per unit weight of forage fed, a 17% greater efficiency in the use of protein, a 43% greater efficiency in the use of calcium, a 47% greater efficiency in the use of phosphorus, and an 80% greater efficiency in the use of the land as a means of converting a small part of its fertility into marketable products of higher values for human sustenance. Thus, through this long chain of effects, the importance of soil fertility restoration in the form of soil treatments brings itself more nearly to the significance it deserves.

Trials With Sheep 1940-41

Because the hay used in the first attempt at a biological assay of effects by soil treatments was not produced under constant soil conditions throughout the trial, the experiment was repeated using the hays grown on soils of the station experiment plots. Lambs were again obtained from the source used previously and the experiment followed the same plan as that of 1939-40. The hays were harvested and stored in good condition. They were from adjacent ranges and all operations had been carried out at the same time and by identical procedures.

The crop yields and the analyses of the forages are given in Table 4. With them is a summary of the feeding data compiled for 98 days of the experiment.

Table 4.—Hay yields and consumption as related to gains by lambs, September 28, 1940, to January 4, 1941, 98 days.*

	Hay from phosphate-treated soils (8 lambs)	Hay from soil treated with lime and phosphate (9 lambs)
Yield per acre, lbs.	3,000	3,812
Nitrogen, %	1.95	2.05
Calcium, %	1.13	1.31
Phosphorus, %	0.226	0.220
Sheep days	784	882
Hay offered per pen, lbs.	3,146.8	3,324.6
Waste recovered, lbs.	1,568	1,496.7
Hay consumed, lbs.	1,578.8	1,827.9
Gain per pen, lbs.	111	145
Gain per head per day, lbs.	0.1408	0.1644
Hay consumed per head per day, lbs.	2.013	2.072
Hay per pound gain, lbs.	14.22	12.6
Protein per pound of gain, lbs.	1.74	1.61
Gain per pound calcium, lbs.	6.23	6.06
Gain per pound phosphorus, lbs.	31.1	36.1
Gain per acre lespedeza, lbs.	210.9	301.5
Difference in yield of hay, %	27.0	
Difference in rate of gain, %	16.6	
Difference in gain per acre, %	43.1	
Difference in concentration of protein, %	4.9	

*Calculations of data in this trial were made in the same manner as for Table 3.

The yields of hay harvested in 1940 averaged somewhat larger than those in 1939, probably due to heavier summer rainfall. From two phosphate ranges the yield for 1940 was 3,000 pounds per acre; that for the two areas treated with both phosphate and limestone 3,812 pounds per acre. The difference in yield, namely, 27%, was greater than that obtained in 1939 when liming resulted in an increase of 21% in the forage yield.

Animal Increases as Indices of Forage Efficiency

The data in Table 4 show the 98-day feeding results obtained in 1940-41. The figures for the gains and the hay consumed are comparable to those obtained in 1939. Both pens consumed about the same amount of hay, namely, 2.0 pounds per head per day as compared to 2.1 pounds for the preceding year. The lambs receiving phosphated hay gained an average of 13.8 pounds per head in this 98-day period,

an average of 0.1408 pound per day. Those given hay grown on land receiving both phosphate and lime gained as an average, a total of 16.1 pounds per head during this period, an average of 0.1644 pound per head per day. This difference in rate of gain is more than 16%. Further calculations in a manner similar to those in the first trial with sheep show that the sheep receiving phosphated hay produced a pound of gain for each 14 pounds of hay consumed, while those receiving the limed and phosphated hay produced a pound of gain from only 12.6 pounds of hay. Accordingly, the phosphated hay would produce 210 pounds of animal gain per acre, while that grown on the phosphated and limed land would produce 301 pounds per acre. When considered for hay only, these figures are high because part of the gain comes from the supplement fed, but, since the quantity of supplement supplied was constant, the figures are comparable. This is a difference in animal production per acre of more than 43% because of soil treatments as contrasted to differences of only 27% in the tonnage yields of the two hays because of soil treatments.

The following facts stand out prominently regarding soil treatments as they are reflected by animal behaviors: Soil treatments in the field may modify the chemical composition of forages; animal gains made from these different forages reflect differences much greater than are the differences in chemical composition as commonly evaluated, according to methods of feed analyses; the nutritive efficiencies of elements contributed by the soil and of the compounds formed by the plants apparently are much improved by soil treatments; the tonnage yields per acre of forage are not the complete measure of the values to be derived from soil treatments; some other elements, compounds, or complexes in addition to increased mineral content in the forage derived through soil treatments seem responsible for these improvements in animal gain, differences in the calcium and phosphorus contents alone apparently being too small to account directly for the wide differences in animal gain;

finally, if soil treatments are to be measured for their fullest value in better agriculture, their measure in the form of a biological assay with animals seems necessary.

Laboratory Animals and Assay of Soil Fertility Treatments

As a support for the results obtained from the experiments with sheep, more detailed data were gathered by feeding lespedeza hay from the same source to rabbits. Two pens each containing three young female chinchilla rabbits were fed the hay used for sheep in 1939. The rabbits received all the hay they would eat along with a daily supplement of 20 grams of oats per head per day while they were small and 30 grams later. They were fed in screen-floored pens. Both the feces and the urine were collected to permit a chemical balance of the outgo against the intake in the ration of hay and oats. Complete records were kept of the hay given and of the waste removed. Tables 5 and 6 give the results of feed consumption and of animal growth for a period of 100 days, extending from March 6 to June 13. The digestibility and other evaluations are given in Table 6.

Table 5.—Hay consumed and rabbit gains during 100 days, March 6 to June 13, 1940, average of three rabbits in each pen.

	Lespedeza hay from soil treated with phosphate (pen 1)	Lespedeza hay from soil treated with phosphate and lime (pen 2)
Hay consumed, grams	22,531	23,297
Hay consumed per head per day, grams	75.1	77.6
Rabbit gain per pen, grams	2,325	3,214
Grams hay per gram gain, grams*	9.69	7.24
Average gain per rabbit per 100 days, grams	775	1,071

*When the gain is calculated as though produced by the hay only.

Rabbit Gains as Indices of Differences in Efficiency Of Forage as Feed

The figures obtained in the experiments with rabbits (Table 5) show results in close agreement with those obtained with sheep. The rabbits fed the hay from limed soil ate only about 3% more than those fed the phosphated hay,

but made 38% more gain. The quantity of hay necessary to produce a unit of gain was also in agreement with the results obtained with sheep. While 9.69 grams of phosphated hay were required for each gram of gain, only 7.24 grams of the hay that was phosphated and limed were necessary for the same gain. This is a difference of nearly 34%. That all of the gains made by the rabbits should be in such close agreement with those obtained with the sheep suggests the possibility of using these smaller animals as bioassay agents.

Table 6.—Digestibility data for lespedeza hays from different soils.

	From soil treated with phosphate	From soil treated with phosphate and lime
Gain per gram of hay, grams*	0.103	0.138
Gain per gram of oats, grams*	0.353	0.487
Gain per gram oats and hay, grams	0.0797	0.1075
Digestibility of dry matter, %	64.8	61.4
Gain per gram nitrogen fed, grams	5.15	5.22
Digestibility of nitrogen, %	55.5	57.6
Gain per gram nitrogen retained grams	13.4	14.0
Gain per gram calcium fed, grams	10.94	13.07
Digestibility of calcium, %	62.9	56.5
Digestibility of phosphorus, %	40.3	28.8
Calcium voided in urine per gram calcium fed, grams	0.169	0.084
Gain per gram calcium retained, grams	23.3	27.7
Gain per gram phosphorus fed, grams	48.7	49.4
Phosphorus voided in urine per gram phosphorus fed, grams	0.0259	0.0158
Gain per gram phosphorus retained, grams	124	180
Gain per gram feces, grams	0.227	0.279

*When the entire ration, grain and hay, is considered and the gain divided by the weight of oats, or of hay, consumed.

The digestibility of the two different hays was determined from the analyses of all materials fed and from the analyses of the urine and feces. Only a small portion of the results from the calculations are included in Table 6, but these figures give additional information regarding the efficiency of the two hays. The hay from soil receiving both phosphate and lime contained a greater quantity of nitrogen, phosphorus, and calcium than the hay grown on soil receiving only phosphate. However, the differences in digestibility

and retention of the different elements for which analyses were made were much greater than these analyses indicate.

Despite the greater gains made by the animals on the hay from the limed and phosphated soil, they digested only 61% of the bulk ingested, while the animals fed hay from the soil which received only phosphate digested 65% of the bulk ingested. Similarly, the calcium in the phosphated and limed hay was digested to the extent of 56% and to 63% in the phosphated hay. For the phosphorus in the hays the corresponding figures were 29% and 42% digestible. In spite of the higher digestibility of the bulk, of the calcium, and of the phosphorus for the hay given only the single soil treatment, the gains per gram of calcium and per gram of phosphorus fed were higher for the hay on soil treated with both lime and phosphate.

The rabbits fed the limed and phosphated hay produced 5.22 grams gain for each gram of nitrogen fed, while the phosphated hay produced 5.15 grams gain for each gram of nitrogen fed. Calculations of the amount of nitrogen fed and voided show that for each gram of nitrogen retained in the animal body, those animals fed the phosphated hay made 13.4 grams of gain, while those receiving hay from the limed and phosphated land used this same unit of protein to build a body gain of 14.0 grams. This may seem to be a small difference, but it points to either a better balanced protein or a more efficient utilization of the protein when offered in combination with other items delivered in the feed.

Efficiency of Calcium

When the growth and digestion figures are calculated on the basis of the calcium, the results are more striking with even a higher efficiency than that for protein. Even though the difference in the calcium concentration within the hays was relatively small, yet the difference in gain per unit of calcium fed and retained is large. The pen of rabbits fed the phosphated hay made a gain of 10.9 grams for each gram of

calcium supplied and a gain of 23.2 grams for each gram retained in the body, whereas the corresponding figures for the rabbits fed the hay from the phosphated and limed soils show gains of 13.7 grams and 27.1 grams, respectively.

It is significant that the total amount of calcium retained by both pens was almost the same, namely, 53.1% and 52.9%, yet the rabbits on the limed hay made much more rapid gains per unit of calcium retained. This would indicate that neither of these hays was failing to deliver an ample amount of calcium, but the presence of the calcium in the soil influenced the physiology of the plants so that they provided a forage of which the calcium content could be more efficiently utilized by the animals.

Efficiency of Phosphorus

The phosphorus digestion and retention also show striking differences according to soil treatment. For each gram of phosphorus given, the animals fed on the phosphated hay produced 47.7 grams of gain, while on the phosphated and limed hay the gain was 49.4 grams. If the gains are computed on the basis of the phosphate retained in the body, then the phosphated hay produced 123 grams of gain, whereas the hay from the phosphate and lime treated plots produced 180 grams gain for each gram retained. This is a difference of over 46%. This is again significant since the phosphorus treatment on both hays was constant. This also indicates that the addition of the limestone produced physiological differences in the plants which had a pronounced effect on the utilization and efficiency of the phosphorus. Although the rabbits which were fed the hay grown on the phosphated soil retained a slightly larger percentage of the total amount of nitrogen, calcium, and phosphorus given them, the gain made per unit of these materials retained in the body was much greater where the plants were grown on soil well supplied with lime.

It is a striking fact that although the rabbits were fed the greater quantities of calcium and phosphorus in the limed

hay, yet they excreted less of both of these elements in the urine. This tends further to suggest that when these elements were digested out of the feed, the hay which received only phosphate must have been deficient in something and thus prevented the calcium and phosphorus from being effectively utilized.

Regarding the composition of these hays there is the further fact that the animals fed the phosphated hay produced 0.228 gram of gain for each gram of feces excreted, while on the limed and phosphated hay the corresponding gain was 0.279 gram, an increase of 23%. The animals fed the phosphated hay excreted 23% more waste to make the same amount of gain as did those fed on hay receiving both phosphate and lime.

Summary and Discussion

From chemical analyses and digestion measurements made on sheep and rabbits, it is evident that the increase in tonnage per acre is an insufficient measure of the value of a soil treatment. Lespedeza grown on soil receiving both lime and phosphate produced from 20 to 26% higher yields than where phosphate alone was applied. However, when the same hays were fed to experimental animals the difference in meat as pounds became 60 to 80%. There were no great differences in the concentrations of calcium or phosphorus in these hays, yet in terms of animal nutrition it is forcefully suggested that the presence of the lime must have altered the physiology of the lespedeza plants during growth. This limed hay apparently contained certain substances essential for animal growth and mineral utilization which was not determined by the usual chemical analyses, measuring the mineral elements and protein. Though the increased quantity of protein is in approximate agreement with better animal growth, yet the gains were greater per unit of the protein supplied in the limed hay. This indicates delivery of other substances necessary for animal metabolism by this soil treatment and that analyses for the common feed con-

stituents as now practiced are not sufficient to measure the value of soil treatments. It seems that some type of biological assay is the only means by which these improvements can be measured.

The correlation between the results obtained from sheep and rabbits is so close that it appears possible to eliminate the larger and more expensive animals, and use laboratory animals in the experiments, then interpret the results in equivalents of farm animals. If a definite correlation between the nutritive behavior of rabbits and larger animals can be established, it will be possible to use many more soil areas under treatment and obtain biological assays with laboratory animals when with sheep or cattle such assay would be impossible, or limited to few expensive and time-consuming trials.

The foregoing report has dealt only with forages grown on soils of different calcium treatment. If calcium can bring about such marked differences, it is logical to believe that other fertility elements which play an important role in the growth of plants might also influence a plant's composition sufficiently to be reflected by the test animals. It is essential that thought be given to the use of this refined measure by means of animal assays for determining the influences by other soil treatments whose effects are not yet detectable in terms of tonnage increases.

CHAPTER XVIII

Studies on the Interrelation of Fats, Carbohydrates, and B-Vitamins in Rat Nutrition*

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Introduction

It has been demonstrated in this laboratory that weanling rats fed *ad libitum* rations containing lactose and corn oil grew at a rate inferior to that obtained with butterfat. When glucose was the carbohydrate no difference could be found in rats fed either fat in the presence of lactose. Deuel, *et al.* fed weanling rats an unextracted, mineralized skim milk powder ration to which was added one of the following fats: butter, corn, cottonseed, olive, peanut, soybean, or margarine. They found no significant differences in growth rate, body composition, or pregnancy and lactation performance of rats fed rations containing the various fats. Zialcita and Mitchell also concluded that corn oil and butterfat are essentially equal in growth promoting value for the rat. The paired method of feeding was employed. The ration consisted of 60 parts of ether-extracted skim milk powder and 27 parts of the fat to be tested plus

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7 parts of casein, 6 parts of a salt mixture, and fat-soluble and synthetic B-vitamins. Although these investigators did not entirely fulfill the conditions defined by us, the data were interpreted to disprove our original observations.

Deuel and Movitt (6) found that in *free choice* experiments rats chose certain diets containing diacetyl or commercial butter flavoring in preference to the unflavored diet. It was concluded that the superiority of butterfat over certain vegetable oils reported by Schantz, Elvehjem, and Hart "is in all probability to be traced to the fact that weanling rats prefer a butter flavor and will eat more of such a diet." In contrast, Boutwell, *et al.* used the *single choice* technique with *ad libitum* feeding and found that the removal of the flavoring agents from butterfat by chromatography or the addition of one such agent, diacetyl, to corn oil had little or no effect on the average daily food intake and average gain in body weight of rats fed certain purified rations. Flavor was also ruled out because rats showed no difference in food consumption or growth when fed rations in which glucose was substituted for lactose.

In explanation of the superior nutritive value of butterfat over corn oil in certain rations, Boutwell, *et al.* suggested that the substitution of corn oil for butterfat resulted in a decreased sythesis of vitamins by the intestinal flora. It is well recognized that changes in the kind of dietary carbohydrate may be reflected in the amount of vitamins synthesized by the intestinal microorganisms. There are no data in the literature which show that the kind of dietary fat may have a similar effect. However, Mannering, *et al.* showed that the isocaloric substitution of fat for dextrin, in a ration restricted in riboflavin content but adequate in other respects, decreased the growth of rats by lowering the bacterial synthesis of riboflavin. There are *in vitro* studies which show that different fats may have varying effects on the growth of bacteria. Strong and Carpenter found stearic and oleic acids were stimulatory to *Lactobacil-*

lus casei. Palmitic and linoleic acids had an inhibitory effect. Feeney and Strong obtained an ether soluble fraction from blood which stimulated the growth of the same organism.

The present study was undertaken to clarify that property of fats which is responsible for the observations of Boutwell and coworkers and to interpret, if possible, the disparity in the conclusions of various investigators.

Experimental

Male albino rats of the Sprague-Dawley strain (20 days of age, 5 g. weight range) were placed in individual raised screen cages and fed the experimental diets for six weeks. Food and water were given *ad libitum* each day and food consumption records were kept.

The rations contained carbohydrate 48, purified casein[1] 20, salt mixture[2] 4, and fat (butterfat or corn oil) 28. Three levels of B vitamins were fed as shown in Table I.

Table I.—Composition of Rations.

Component	Vitamin level Medium	High	High plus liver
	per cent	per cent	per cent
Carbohydrate	48	48	48
Casein	20	20	20
Salts	4	4	4
Fat	28	28	28
	mg./100 g.	mg./100 g.	mg./100 g.
Liver extract*			1
Thiamine	0.200	0.500	0.600
Riboflavin	0.300	0.500	0.900
Pyridoxin	0.300	0.625	0.900
Pantothenic acid	1.500	5.0	6.000
Choline	100.0	250.0	200.0
Niacin		0.625	1.000
p-Aminobenzoic acid		30.0	30.0
Inositol		100.0	100.0

*Wilson's whole liver powder, included at the expense of the total solids of the ration not fat.

[1] Four extractions of four hours each with continuous stirring; two with boiling ethanol and two with diethyl ether.

[2] Hegsted, et al. (16).

These levels are arbitrarily designated as medium (or normal), high, and high plus liver. To insure uniformity

among the several rations containing a given level of B vitamins, the proper amounts of the vitamins were incorporated with sufficient casein to enable aliquots to be taken from the same lot of casein for each diet to be mixed. Fat-soluble vitamins were added to both fats so that in addition to the amount naturally present, every 100 g. of ration contained 0.014 mg. calciferol, 0.560 mg. B-carotene,[3] 2.24 mg. a-tocopherol, and 0.210 mg. 2-methyl-1,4-naphthoquinone. The butterfat was prepared by decantation and filtration of melted (60°C.) fresh unsalted sweet cream butter from the University Creamery. The corn oil (Mazola) was obtained on the local wholesale market. Basal rations without the fat were mixed every three weeks. The complete ration including fat was mixed weekly and kept under refrigeration.

The carbohydrates used were as follows:

Galactose, Pfanstiehl *d*-galactose practical
Glucose, cerelose, a pure commercial monohydrate[4]
Starch, commercial corn starch
Dextrin, corn starch autoclaved 3 hours at 15 pounds, dried and ground
Dextri-maltose, Mead, Johnson and Co., salt-free
Sucrose, commercial cane sugar
Fructose, Pfanstiehl, *d*-levulose, C.P.
a-Lactose, Merck, U.S.P. milk sugar[4]
B-Lactose, Borden Company

In one instance the 48 parts of carbohydrate were made up from 24 parts of glucose and 24 parts of galactose so as to represent the hydrolysis products of lactose. In a second case, the 48 parts of carbohydrate were made up from 24 parts of glucose, and 24 parts of fructose, the hydrolysis products of sucrose. The carbohydrate and fat combinations as fed are shown in Table II.

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[3] Ninety per cent B-carotene. Nutritional Research Associates, Inc., South Whitley, Indiana.

[4] The water of crystallization was not considered in formulating rations.

Table II.—Growth of Rats Fed Various Combinations of Fat, Carbohydrate, and Water-Soluble Vitamins (6 Weeks)

Vitamin level	Medium			High			High plus liver		
Fat	Butter	Corn	Dif.[2]	Butter	Corn	Dif.[2]	Butter	Corn	Dif.[2]
	g.	g.		g.	g.		g.	g.	
Galactose									
Galactose-Glucose[1]	185 (3)*	179 (3)*	6	158 (3)* / 180 (18)	162 (3)* / 182 (18)	—4 / —2			
Glucose	172 (12)	175 (12)	—3	187 (18)	183 (18)	4	212 (12)	209 (12)	3
Starch	192 (12)	169 (12)	23	188 (18)	185 (18)	3	215 (6)	218 (6)	—3
Dextrin	187 (6)	169 (6)	18	174 (18)	168 (18)	6	203 (6)	202 (6)	1
Dextri-maltose	199 (6)	176 (6)	23	181 (18)	168 (18)	13	205 (6)	208 (6)	—3
Fructose-Glucose[1]	190 (6)	164 (6)	26				200 (3)*	192 (3)*	8
Sucrose	185 (18)	148 (18)	37	190 (18)	166 (18)	24	209 (6)	203 (6)	6
a-Lactose	118 (12)	83 (12)	35	158 (60)	123 (60)	35	167 (12)	145 (12)	22
B-Lactose				141 (18)	118 (18)	23			

* Except for these groups, all groups consisted of six animals each. The figures in parentheses represent the total number of animals used in computing the average. Figures of 12, 18, or 60 animals indicate the experiment was run twice, three times, or ten times, respectively.

[1] Each of the component carbohydrates constituted 24 parts of the ration.

[2] Positive values indicate the gain made by the butterfat group was greater; negative values indicate the converse.

Growth of weanling rats fed rations containing lactose or sucrose was compared when supplemented with raw pork liver, a very rich source of the B vitamins. No comparison between butterfat and corn oil was attempted with this supplement because, in addition to the vitamins, it supplies appreciable quantities of animal fat. The ration had the following composition: lactose or sucrose 46, crude casein 25, salts 4, and butterfat (with added fat soluble vitamins) 25. The high level of B vitamins (Table II) was incorporated in the ration. A supplement of 2.5 g. of fresh, raw pork liver was given daily to each rat. Six weanling male rats were fed each ration *ad libitum* for 6 weeks. The growth and food consumption are shown in Table IV. Over the entire experimental period of 42 days, the fresh liver supplement contributed 31.5 g. of solids to the ration consumed by each rat.

An *in vitro* experiment was made to determine the effect of the free fatty acids of butterfat and corn oil on the

growth of *Streptococcus lactis*[5] and *Lactobacillus casei*.[6] The organisms were grown on the media described by

Table III.—Growth of L. casei and S. lactis in the Presence of the Free Fatty Acids of Butterfat and Corn Oil

	Galvanometer reading* as a measure of growth			
Organism	L. casei		S. lactis	
Control tubes	53		85	
Fatty acids mg./tube	Butter	Corn	Butter	Corn
0.1	56	103	91	80
0.2	55	108	93	80
0.5	58	101	83	78
1.0	71	96	84	79
2.0	86	92	86	87
4.0	110	99	99	98

* Corrected for the turbidity of the emulsion of fatty acids. The blank tube was set at 100.

Luckey, Briggs, and Elvehjem made complete by the addition of 0.1 mg. of solubilized liver per tube. The techniques of microbiological assays were followed. The free fatty acids were prepared by accepted procedures with care exercised to prevent oxidation. The lower fatty acids of butterfat were removed by steam distillation. Using a laboratory homogenizer, an emulsion of the fatty acids of butterfat and of corn oil in water was prepared, of such concentration that aliquots could be taken to test varying levels of fat per tube. After inoculation, the tubes were incubated at 37°C. for 16 hours and read turbidimetrically in the Evelyn colorimeter. A series of blank tubes containing the same amount of the fat emulsion and at the same dilution as the experimental tubes was read to determine the correction for the turbidity of the fat emulsion. The data are presented in Table III, growth being expressed in terms of galvanometer reading. The instrument was adjusted so that a blank tube which contained no solubilized liver or fat gave a reading of 100. Growth of *L. casei* and *S. lactis* on the complete media without fat was represented by a reading of 53 and 85, respectively.

[5] Now designated as S. faecalis R.

[6] We wish to thank Mr. T. D. Luckey for help in performing this experiment.

Table IV.—Growth and Food Consumption of Rats Supplemented with High Levels of B Vitamins Plus Raw Pork Liver

(Each figure is the average of 6 male rats over a 6 weeks period.)

Ration	Growth	Total consumption (gm.) Ration	Total consumption (gm.) Liver supplement*	Total daily consumption
	g.			
Lactose	215	443	31	11.3
Sucrose	228	450	31	11.5

* Dry basis.

Results

An overall summary of the growth data is presented in Table II. All fat-carbohydrate combinations shown within each vitamin level were fed concurrently at least once. However, rations containing different levels of vitamins were fed at different times. Thus the better growth which resulted in certain groups fed the medium level of vitamins as compared to the high level may be attributed to variations in rats from time to time.

In the series fed high vitamin rations plus liver, similar rates of growth were found regardless of the kind of carbohydrate or fat in the ration with the exception of the animals fed lactose. With lactose as the carbohydrate, the group fed butterfat was about 40 g. below the average groups fed the same fat and the other carbohydrates tested. The substitution of corn oil for butterfat caused a further drop in growth of about 20 g. in 6 weeks.

The growth of rats fed the purified rations containing a high vitamin level with no crude vitamin carrier was more variable. Animals receiving galactose as 48 parts of the diet grew rather poorly. This was attributed to metabolic difficulty in utilizing such a level of galactose. All six rats developed bilateral cataract by the fifth week and present investigation (unpublished) indicates that rats fed such a ration excrete a large proportion of the dietary galactose in the urine. There was no difference in the growth promoting value of the two fats on this ration. With the carbohydrate portion of the diet composed of equal amounts

of galactose and glucose, good growth was obtained with either fat. No cataract was observed. The groups fed butterfat and glucose-galactose mixture, glucose, starch, dextrimaltose, sucrose, and probably dextrin all maintained superior growth. This was true also of groups fed corn oil and galactose-glucose mixture, glucose, and starch. A small but definite drop was noted if corn oil was fed with dextrin, dextri-maltose, or sucrose. Again, as was found with high vitamin-liver rations, the growth of animals fed lactose was inferior. In 10 experiments with the a-lactose, high vitamin ration totaling 120 animals (60 on each fat) the growth on the corn oil diet averaged 35 g. below that obtained on the butterfat regime at the end of 6 weeks. A statistical analysis of the growth data of rats fed rations at the high level of vitamins (Table V) showed the superiority of butterfat

Table V.—Food Consumption, Growth, and Statistical Evaluation of Growth Difference of Rats Fed Various Fat and Carbohydrate Combinations in Rations Supplemented with a High Level of B-Vitamins[1]

	Food Consumption		Growth		Growth	Analysis
	Butter-	Corn	Butter-	Corn	differ-	of
Carbohydrate	fat	oil	fat	oil	ence	variance[3]
	g./day		g./6 weeks		g.	F
Galactose	9.5	10.1	158	162		
Galactose-Glucose[2]	11.1	10.9	179.8	182.1	2.3	0.06
Glucose	11.2	11.0	187.0	182.8	4.2	0.21
Starch	10.5	10.4	187.6	185.4	2.2	0.06
Dextrin	10.2	10.0	173.9	167.9	6.0	0.43
Dextri-maltose	11.2	10.2	181.1	168.4	12.7	1.95
Sucrose	11.2	10.1	189.7	166.1	23.6	6.72
α-Lactose	10.1	7.7	149.3	123.9	25.4	7.77
B-Lactose	10.1	8.2	140.7	118.3	22.4	6.01

[1] These data are taken from the same experiments summarized in Table II, high vitamin column. Each figure is the average of 18 animals, except with galactose as the sole carbohydrate where 3 animals were fed each fat.

[2] Each of the two component carbohydrates constituted 24 parts of the total ration.

[3] The 1% value for F is given as 6.72 and the 5% value as 3.87 (one degree of freedom/280 degrees of freedom) in the "Statistical Tables for Biological, Agricultural, and Medical Research" by R. A. Fisher and F. Yates, (Oliver and Boyd, 1938), pp. 31 and 33. We wish to thank Dr. James H. Shaw for help in the statistical analysis.

was highly significant when either sucrose or a-lactose was the carbohydrate. These data were well suited for statistical

treatment because of the uniform, controlled conditions of the study. In three separate experiments, 96 weanling rats born on the same day and in a 5 g. weight range were divided into groups of 6 and fed 16 different diets. Thus a total of 18 rats represented each diet in the analysis of variance.

Rats fed a medium level of the B-complex and butterfat grew uniformly well on the galactose-glucose mixture, starch, dextrin, the fructose-glucose mixture, and sucrose diets. The corresponding animals on the glucose diet averaged 15 to 25 g. less. With the exception of the galactose-glucose and glucose groups, animals fed corn oil averaged 18 to 37 g. less than the butterfat controls. At this vitamin level, rats grew only 2.8 and 2.0 g. per day when fed the lactose-butterfat and lactose-corn oil ration, respectively.

Rats responded similarly to changes in fat and vitamin level when fed rations which contained either sucrose or the mixture of fructose and glucose equivalent to sucrose on a molecular basis. Lactose, which is considered to be slowly resolved to its component monosaccharides in the intestinal tract, differed greatly from the mixture of galactose

Table VI.—Food Consumption of Rats Fed Butterfat or Corn Oil in a Lactose High Vitamin Diet

(Each figure is the average of 6 rats.)

Days (inclusive)	Butterfat ration	Corn oil ration
	g.	g.
1— 5	21	20
6—10	32	25
15—42	360	265

and glucose as changes were made in the dietary fat and vitamin level. The greater solubility and apparent sweetness of B-lactose over ordinary milk sugar was not reflected in the growth response of rats. Rather, in three separate experiments B-lactose tended to allow a smaller gain in body weight than a-lactose. Ershoff and Deuel found B-lactose was more "lethal" to young rats than a-lactose.

Food consumption was followed in all experiments. The average gain in six weeks and the average daily food intake

of rats from one experiment at the high level of B-vitamins are given in Table V. The data show that food consumption parallels growth in all experiments. Typical food consumption data for rats fed the purified lactose ration at the high vitamin level with butterfat and corn oil are given in greater detail in Table VI. During the first five days there was no difference in the amount of food consumed by the two groups. The group fed butterfat began to eat more than the group fed corn oil between the sixth and tenth day. After two weeks, consumption differed markedly. If palatability were a factor in determining the growth response of rats to these two fats as contended by Deuel and Movitt, a difference in consumption should be apparent from the start of the experiment.

No gross pathology of the internal organs was observed in rats fed any of the diets described. The fresh weight of the cecum of animals fed these rations, characterized by 48% of carbohydrate and 28% of either fat, was usually in the range of 2 to 3 g. at the end of an experiment with the exception of rats on lactose rations. Ceca ranged from 3.5 to 10 or more g. with either a- or B-lactose in the diet. Considerable water was present. It was noticed that the cecal contents of rats fed the butterfat-lactose rations were light yellow in color and usually quite free of gas. In contrast, the cecal contents of the corn oil-lactose group were gray and gas occluded with an odor of putrification. H_2S was easily driven off and detected with lead acetate. This difference in color was reflected in the feces of the animals in these respective groups, *i.e.*, those from the butterfat-lactose animals were light colored, while those from the corn oil-lactose group were black. Cream colored feces were cometimes noted when butterfat was fed with any carbohydrate.

The general appearance of rats fed corn oil with lactose was poor at all vitamin levels. This was also true of rats fed starch, dextrin, dextri-maltose, fructose-glucose mixture, and sucrose with a medium level of vitamins and occasion-

ally of rats fed the high vitamin corn oil-sucrose ration. The chief gross symptoms were "bloody" nose and head, poor fur, and extensive symmetrical abdominal alopecia. Diarrhea was prevalent among rats fed lactose with corn oil, especially during the first 3 weeks, but was absent or much less evident among the rats fed the ration with butterfat. A mild form of dermatitis of the paws was found only among animals fed the lactose ration with corn oil.

The *in vitro* studies showed that the addition of the fatty acids of either fat had little effect on the growth of *S. lactis* up to levels of 2.0 mg. per tube. Complete inhibition of growth apparently resulted from the addition of 4.0 mg. The growth of *L. casei* was not inhibited with levels of the fatty acids of butterfat up to 0.5 mg. per tube, but levels of 1.0 and 2.0 mg. showed increasing inhibition, which became complete at levels of 4.0 mg. In contrast, the free fatty acids of corn oil inhibited the growth of *L. casei* at all levels tested.

Discussion

The data indicate that the apparent requirement of the rat for vitamins of the B-complex may be altered by a change in the kind of dietary fat, depending upon the kind of carbohydrate used in the ration. If this phenomenon were a function of a difference in metabolism of the fats studied, it would be expected to be manifest at certain vitamin levels irrespective of the carbohydrate fed, but this was not the case. Apparently the flora existing by virtue of the diets containing sucrose, a fructose-glucose mixture, starch, dextrin, dextri-maltose, and lactose was labile to the kind of fat fed. The data obtained on the sucrose ration will serve to illustrate this point. The groups of rats which received butterfat gained 185 g. at the medium level of vitamins, 189 g. at the high level, and 209 g. in 6 weeks at the high level of vitamins plus 1 per cent of whole liver concentrate. In contrast, rats fed the above rations with the butterfat replaced by corn oil grew 148, 166, and 203 g., respectively. At the

lowest (medium) level of vitamins fed, growth of rats receiving butterfat surpassed those on corn oil by an average of 37 g. in 6 weeks. The superiority of butterfat was nonexistent (6 g.) at the high level of vitamins plus whole liver powder. The poor growth of the group receiving the corn oil ration at the medium level of water-soluble vitamins is a reflection of a reduced quantity of vitamins available to the animal from the intestinal flora, since the addition of more synthetic B-vitamins plus liver concentrate allowed these animals to grow at a rate equal to that achieved by those fed butterfat. The B-vitamin content of butterfat is negligible.

The *in vitro* experiment which showed the effect of the fatty acids in butterfat and corn oil on the growth of bacteria was described solely as an analogy to illustrate the probable mode of action of the fats in the interplay of fat, carbohydrate, and B-vitamins in the nutrition of the rat. No implied significance of either organism *in vivo* is intended. If a portion of the vitamin synthesizers or utilizers in the tract were similarly inhibited or allowed to grow, significant differences in the kind and amount of vitamins available to the host would be possible.

The qualitative and quantitative nature of the underlying deficiencies demonstrated in rats fed corn oil in combination with various carbohydrates may not be the same. For example, the riboflavin produced in the intestine of rats was shown to be much greater on diets high in lactose or dextrin as compared to sucrose. The observation that supplements of high levels of thiamine, riboflavin, pyridoxin, pantothenic acid, and choline, in addition to *p*-aminobenzoic acid, inositol, and nicotinic acid improved the growth of rats fed certain corn oil rations indicates that one or more of these vitamins may be involved. Biotin and unknown vitamins are not ruled out since the inclusion of a liver concentrate in the sucrose, dextri-maltose, and lactose diets was more effective than high B-vitamins alone in equalizing the response

of rats to the two fats. Furthermore, an interplay among the vitamins may be operative. McIntire, *et al.* found that supplements of *p*-aminobenzoic acid and inositol stimulated the growth of rats fed purified diets low in thiamine.

In these experiments, the kind of fat had little effect on the growth of rats fed rations which contained glucose or the galactose-glucose mixture. Possibly in the case of these two carbohydrates, which Cori and Cori have found to be most rapidly absorbed, the flora was largely determined by material other than carbohydrate (protein, salts, etc.) and changes in the kind of fat had a negligible effect on this particular flora and its ability to supply the known and unknown vitamins.

No generalization can be made concerning the effect of the mono-, di-, or polysaccharides in the diet on the growth response of the rats. Changes in the kind of dietary fat and level of vitamins caused an equivalent response in the growth of rats fed diets which contained either sucrose or the glucose-fructose mixture. At defined levels of vitamins, the galactose-glucose diets were superior to the lactose diets in growth promoting value, and only in the case of the latter diets was growth affected by a change in the kind of dietary fat. Thus, the depressed rate of growth of rats fed purified diets containing lactose cannot be attributed to the galactose portion of the molecule.

Lactose as found in milk is known to be an entirely adequate carbohydrate for nutrition. However, in contrast to other common dietary carbohydrates, the growth of rats fed lactose in certain purified rations was found to be inferior. Ershoff and Deuel described rations on which rats failed to survive when lactose was substituted for other carbohydrates. From a number of possible explanations, two deserve special consideration: (1) The flora, as determined by purified rations containing large amounts of lactose, may be so completely altered that dietary essentials normally furnished by the intestinal flora, or supplied by natural food in the

case of milk, are not available to the rat. A decrease in the bacteria classified as vitamin synthesizers or an increase in the number of vitamin utilizers, or both, may be responsible. (2) A slow rate of digestion of lactose to its component monosaccharides would also account for the conditions observed in rats fed the purified diets containing lactose. At autopsy, the intestinal tract of rats fed lactose diets is invariably distended due to the presence of the dissacharide which, because of the high osmotic pressure developed, retains considerable quantities of water in the tract. Furthermore, an energy handicap may thus be affected as compared to the readily absorbed carbohydrates, and the presence of the water might tend to inhibit proper absorption of all classes of food material. Essentially the same possibilities were considered by Ershoff and Deuel in explanation of the mortality of rats fed rations which contained 73.2 per cent of lactose.

In support of the first explanation, a number of examples may be cited to show that the growth of rats fed rations containing lactose is correlated with the vitamin content of the ration rather than the level of lactose. Kemmerer, *et al.* showed that a rat required about 35 days to grow 140 g. when fed whole milk alone. Only 2.25 g. of milk solids were required to produce 1 g. gain in body weight. A ration described by Geyer, *et al.* was composed of 50 parts of skim milk powder as the sole source of B-vitamins, minerals, and protein, to which was added 30 parts of fat and 20 parts of lactose, thus bringing the total lactose content to about 45 per cent. Apparently the level of vitamins was critical in this ration. With butterfat, growth of rats over a 6 weeks period was 214 g. in contrast to 172 g. for rats fed the same ration containing corn oil. Rats also grew well on a ration which contained 46 per cent of lactose together with a daily supplement of 2.5 g. of raw pork liver per rat (Table IV). In six weeks, growth was only 13 g. less than that obtained on the same ration containing sucrose. The growth of rats fed various lactose rations is compared with the number of

grams of lactose ingested (Table VII). The amount of ration necessary to produce one gram gain in body weight is also shown. It can be seen that there was a tendency for the rats to utilize more lactose as the vitamin level of the diet was raised. The addition of a high level of vitamins plus liver and casein to a purified ration containing lactose and only a medium level of 5 B-vitamins nearly doubled the growth of rats and, as a corollary, less ration was required to produce one gram gain in body weight. It is apparent that rather large amounts of lactose may be well utilized if adequate amounts of B-vitamins are available. Ershoff and Deuel found that of all substances tested, only liver gave some indication of reducing the mortality of rats on the high lactose diet. It should be pointed out, however, that they ignored the necessity for fat in the utilization of galactose by the rat as shown by Schantz, Elvehjem, and Hart. The final explanation of the peculiar nutritional properties of lactose may well be complex and involve a combination of such factors as lactase activity and intestinal vitamin balance.

Table VII.—Economy of Food Utilization of Rats Fed Lactose and Butterfat in Rations Carrying Various Amounts of Vitamins

	Whole milk	Raw liver High vitamins	Liver powder High vitamins		High vitamins		Medium vitamins	
Source of data	Kemmerer, et al. (23)	Expt. 106*	Expt. 119	Expts. 122 and 126**	Boutwell, et al. (2)	Expts. 88, 89, 93**	Expt. 110**	Expt. 125**
Ration consumed, g.		474	438	411	416	424	355	392
Lactose consumed, g.		212.6	210.2	197.2	199.7	203.5	170	188
Gain, g.	140	215	169	168	145	149	120	116
Grams of ration required to produce 1 g. gain	2.25	2.20	2.59	2.45	2.86	2.77	2.95	3.38
Number of rats	6	6	6	12	12	18	6	6

* See Table IV. ** See Table II.

Weanling rats, when fed *ad libitum* a defined ration in which several carbohydrates could be substituted at specified levels of B-vitamins, showed a superior response to butterfat in comparison to corn oil if supplemented with adequate amounts of the known fat-soluble vitamins. It was found that under many conditions butterfat and corn oil were of equal growth promoting value for the rat. This has also been shown in the extensive studies of Deuel, *et al.* and of Zialcita and Mitchell. However, the latter investigators, in criticizing our data, interpreted their negative results to cover all conditions under which these fats may be fed.

These experiments, showing the influence of fats on the synthesis of water-soluble vitamins in the intestine, raise many questions which cannot be answered at the present writing. Would man subsisting on a diet low in the water-soluble vitamins be further endangered by the consumption of vegetable oils or their products as compared with the animal fats, especially butterfat? The problem is worth investigating.

Summary

1. A change in the kind of dietary fat altered the apparent requirement of the rat for vitamins of the B-complex when sucrose, a fructose-glucose mixture, starch, dextrin, dextri-maltose, or lactose was the carbohydrate in certain rations.

2. On any of the above carbohydrates, rats which received butterfat and a medium level of thiamine, riboflavin, pyridoxin, pantothenic acid, and choline grew at a faster rate than comparable rats fed corn oil. This inferiority of corn oil could be reduced on lactose rations and eliminated on all other rations by raising the level of these vitamins and adding high levels of inositol, *p*-aminobenzoic acid, and nicotinic acid plus 1 per cent of whole liver powder.

3. No difference in growth between the rats receiving

butterfat and those fed corn oil was obtained at any vitamin level when glucose or a galactose-glucose mixture was the carbohydrate portion of the ration.

4. Rats receiving either of the two fats on the lactose ration grew less than animals fed similar rations containing other carbohydrates, but this inferiority decreased as the level of the water-soluble vitamins was increased. The galactose *per se* was not responsible for this retarded growth.

5. Possible explanations of the observed phenomena are briefly discussed in the text.

CHAPTER XIX

Corn and Wheat Embryo

Each Year Hundreds of Millions of Pounds of Human Food Are Lost

Presented by
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at the
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FOREWORD

The thesis for this discussion may be outlined as follows: The Department of Agriculture, National Research Council and Federal Security Agency have emphasized, through their respective chiefs, that the factors likely to be lacking in the American diet, and likely to be lacking in the diet of people we must help feed in the occupied countries, are the B vitamins, proteins and essential minerals. Why has this condition developed?

This shortage in adequate nutrition has come about largely because it was necessary to remove the germ, or embryo, of the grains we eat, in both wheat and corn so that the degerminated products would not deteriorate.

Because of this removal of the essential food parts of the grain, pure vitamins and mineral enrichment have been made mandatory in bread and cereals.

All nutritionists agree that "enrichment" replaces only a part of the essentials that are found in the embryo of wheat and corn; the loss of high quality protein being at

least as significant nutritionally. Until ten years ago the germ of the grain could not be well utilized because they could not be made stable, they would become rancid.

Wheat and corn embryo are being perfectly stabilized in a successful manufacturing business by solvent extraction at low temperatures with the B vitamins, protein and minerals unimpaired. Authoritative experiments reveal that the protein of defatted wheat and corn embryo is equal in biologic value to animal proteins.

Therefore, it is perfectly obvious that immediate steps should be taken (1) to conserve these valuable substances by a broadly conceived program for processing and utilizing these cereal germs, (2) to initiate a plan by which the same educational pressure that has been given the pure vitamin enrichment program, be given to a program for the widest possible use of these valuable foods by our own people, (3) to determine the widest possible utilization of these cereal germs by the nations who are now getting food from us and will require our food supply after the war.

This outline is given to present the facts so that these agencies and the nation as a whole may become more aware of the nutritional significance of corn germ and wheat germ.

The shortage of food is upon us. The United States Department of Agriculture, Federal Security Agency and the National Research Council, cannot knowingly ignore the loss of 800 million pounds of human food each year.

CORN AND WHEAT EMBRYO—THEIR UTILIZATION FOR HUMAN FOOD

What Is The Embryo?

It may be well to open this discussion with a reference to a study recently reported on the degerminating of corn. It is a work by Felix Grandel in the German publication "Fats and Soaps", (Vol. 49, Page 5, 1942.) Dr. Grandel had difficulty in completely removing the germ from the corn

kernel. In his report he describes a new method of determining the exact amount of germ in the corn kernel. Laboratory Albino rats each receive 50 individually weighed corn seeds. The rats bite off the stem end, gnaw the germ or embryo out of grain perfectly, leaving the endosperm untouched. Thus, by weighing the endosperm, Dr. Grandel determines the quantity of germ or embryo in the corn. He states that no careful mechanical method, he has been able to devise, can equal the completeness with which the rats remove the germ and shun the endosperm.

Americans who eat hundreds of millions of pounds annually of corn meal (endosperm), should be interested in this phenomenon. Most of corn and wheat we use for human food, is degerminated. Millers and processors must remove the germ very completely, because even a trace of the germ will cause the corn flakes, corn meal, grits and other products made from corn to become rancid. The same is true for most wheat products.

Wheat germ and corn germ are parts of our cereals, the miller regretfully discards, because if he does not remove them, the products he stores and ships will deteriorate. I say regretfully, because every miller knows that taking out these germs removes a valuable, negotiable factor—taste, the lack of which, more than any other factor, has been responsible for the persistent decline of consumption of flour over the last quarter century.

When our ancestors took the whole wheat or whole corn down to the mill, and brought back the flour, they had a flour infinitely better nutritionally than the finest enriched wheat or corn flour; and, what is just as important, it tasted better.

Let us assume that the problem of stability of the germ could be solved and that the germ would "keep" indefinitely. Would that change our attitude and impel us to return the germ to the grain? That would depend, of course, on how valuable the germ is. Has it anything of value besides taste

and flavor? Is it a byproduct or is it the essential product? Nature points the way by directing the rat to gnaw out the embryo. The embryo of the grain is the essential part of the grain. The embryo is the egg of the seed. It is, physiologically, like the egg of a hen. Both are embryos. It is only recently that we have become aware of the nutritional quality of the embryo or germ. Less than a score of years ago, we knew little about the B complex vitamins, or the difference in biologic values of proteins. But Nature, who directs the rat to remove the germ and discard all else, has taught her animals to be "choosy"; to look for the germ or egg of the grain. She says what amounts to this: "That is where the essential food values are; the rest of the grain is protection and food for that embryo when it is placed in the soil to grow into the new plant.

We would expect the germ or germinating part of the grain to have all that will sustain life—complete protein, minerals and vitamins, as indeed we have found it has. The protective part, the endosperm, may be quite different, and limited in its values; and this too, we have found to be true. Thus we have the amazing situation of nine tenths of the cereals consumed in the United States being made of grain from which the essential values are discarded, and the limited values conserved.

We hold official hearings; we tell the American public that they do not eat right; we encourage the manufacture of pure vitamins and their use in foods; the Federal Security Agency assumes the power to force the inclusion of these pure vitamins. But, we are unbelievably slow to encourage putting back in the diet, the embryo of wheat and corn we have taken out, notwithstanding the indisputable fact that our low state of nutrition (that the Department of Agriculture, National Research Council and the Federal Security Agency view with such alarm,) has been brought about largely through the removal of these essential parts of the grain.

But modern nutritional science will not be denied. It keeps pounding on our intelligence. These cereal germs . . . protein, equal biologically to meat protein; no other plant protein of such high quality available in such large quantities; the richest natural source of the B complex vitamins taken as a whole; thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, inositol, biotin, folic acid . . . cereal germs, the richest food substances known in iron, phosphorus, copper and manganese . . . hundreds of millions of pounds available for human food each year if the germ can be made stable and yet lose none of its essential values.

No other food contains as much critical food value for its weight as wheat germ and corn germ. That statement needs repetition. No other food contains as much critical food value for its weight as wheat germ and corn germ. Here is a new wealth. No new crops must be grown to get this wealth. We have it now. It needs only processing machinery, no more critical than soybean processing machinery, to save for humans everywhere in this critical hour of food shortage, the hundreds of millions of pounds of irreplaceable human food, food the world is begging for, food now diverted to animal feeds, largely denatured in processing, and much of it actually destroyed. All this is ours, simply and easily, if we can stabilize these cereal germs.

Grain Embryo Stabilized

It is because this problem is completely and thoroughly solved that I must mention as an integral part of this development the VioBin Corporation of Monticello, Illinois, who are producing wheat germ and corn germ which are completely stable. They have been doing it for ten years. None of the B complex, protein and mineral values of the cereal germs is destroyed in this processing. These values are actually concentrated because of defatting and dehydrating by solvent extraction at low temperatures. It seems strange that at this late date that anyone must be reassured that we stabilize the germ so that it keeps perfectly. Here

are a few examples: Defatted wheat germ was sent in quantity to Peru, South America in the Interior as part of the treatment for lepers. It was on the sea for months, then carried to the Interior of Peru; afterward fed over a number of weeks. It kept perfectly. Packages of defatted wheat germ nine years old cannot be distinguished from that made last week. 300,000 packages of defatted wheat germ, processed in Monticello, Illinois, are shipped, stored, packaged and sold in Canada in paper packages each year. Not a package has ever been returned because of rancidity. The packaged product has been sold in this country for many years. Not a package has ever been returned because of rancidity. Two thousand packages of defatted wheat germ were recently sent to Russia as a gift for Russian Relief. They arrived at their destination in perfect condition. Prenatal clinics of the city of Chicago have been using defatted wheat germ for five years. Never has there been a complaint of deterioration. There is nothing mysterious about this process. If you remove most of the fat, the product will "keep". If you remove the fat at low temperatures you retain the heat labile factors in the defatted portion.

The defatted wheat germ has been on the market for ten years. The defatted corn germ was only recently introduced. For the first time, corn germ has been made available as a human food. It is being sold, now, today. Its stability, its flavor, its use in foods are established. For the first time, this essential part of the corn has been made available for human food. Would it be more dramatic if this were a new formula, a new vitamin, some new chemical compound, to provide millions of children with the stuff that will help save them from starvation and pestilence? More dramatic perhaps, but certainly not more important.

Nutritional Values of Grain Embryo

In this short discussion there is no time to adequately deal with the B vitamins, protein and mineral values in defatted wheat and corn germ. Here are just a few thoughts on the

intrinsic values in these foods. Man, for at least 4000 years, derived his B vitamins largely from grains. Studies made in England reveal that 100 years ago the diet of the very poor was richer in B vitamins than our average diet today. The source of most of the B vitamins was the whole grains, the vitamins found most abundantly in the part of the grain that we discard—the germ or embryo. All nutritionists know well enough that enrichment with thiamin, riboflavin and niacin, even if added to ten times their natural presence in grains will not replace the B vitamins in the natural germ. It is enough to say, that it is an erroneous assumption that the added vitamins will give the same physiological response as the same amount of vitamins from the natural embryo of the grain. But there is an even more significant reason expressed clearly by Dr. Agnes Fay Morgan of the University of California in 1941 (American Journal of Digestive Diseases Vol. 8, No. 5). What she said at that time has been emphasized by the last two years of research. I quote, "We know only part of the truth as yet about the number and amount of vitamins required for health . . . there are evidences from work with animals that a nice equilibrium exists among some of the vitamins and also among certain of the minerals, so that an undue excess of one may topple the whole structure which might remain fairly stable with a relative deficiency in all." She goes on to outline an experiment with dogs to prove her point and then makes this significant statement. She says, "Partial deficiencies in several necessary factors, not complete deficiency in any one, characterize our modern diet. It may be unsafe to add rich amounts of one of these factors, for example, nicotinic acid or thiamin without providing equally for all the others, including the powerful unknowns." *Powerful unknowns*, indeed; if you asked other nutritionists of equally high rank, the great majority would agree with her. They would agree with her, too, in her belief that many of these powerful unknowns are found in the embryo of the grains.

Now let us consider the vitamins lysine, tryptophane and

the six or seven other indispensable amino acids. I said "vitamins". My authority is the great Osborne who laid the foundation for our understanding of the amino acids, who said that he and his associate, Mendel would have considered the amino acids as vitamins, had they not known that the amino acids were part of the protein molecule. So, I repeat the question, "What about lysine and tryptophane both lacking in degerminated wheat and degerminated corn—the kind we eat?" "Are not lysine and tryptophane as likely to be lacking in the diet, as, let us say, riboflavin?" I have deliberately chosen riboflavin for comparison. In a very significant work of Williams and his associates of Rochester, Minnesota, (Jl. of Nutrition 25, 361) they were unable to observe any serious disturbance as a result of prolonged lack of riboflavin in special diets fed to patients and designed to be free of riboflavin. Where, then, is the proof that there is a riboflavin deficiency in the American diet, and what are the symptoms of such a deficiency? Of course, there is such a deficiency, but today nobody knows what it is. The suggestion that critical evidence would show that lysine, and tryptophane are at least equal in critical nutritional significance to any of the "enrichment" vitamins is certainly not an overstatement because experiment after experiment have revealed the indispensability of these amino acids in both animals and humans. So you see why I contend that these cereal germs contain substances just as essential to our nutrition as the pure vitamins. The logical intelligent viewpoint is to put them back; to remedy the condition that has largely developed by taking them out.

Cereal Germ Protein

Let us go on with the matter of proteins in cereal germs. My first scientific exhibit is a report by Dr. Harriet Chick in Lancet, (Vol. 1, Page 405, April, 1942) dealing with the values of the germ of wheat as related to the endosperm. Commenting on this epoch-making work is a full page editorial in the Journal of the American Medical Association,

September 21, 1942. It states, "Much has been said about the vitamins of wheat but relatively little of its protein content. Yet protein is just as necessary for life as vitamins perhaps, and even more so, because more of it is required to maintain health and efficiency."

I quote without comment from this same editorial, "The point to be emphasized is that the proteins of the germ are composed of amino acids, which are able to supplement those of the gluten and thus raise the biological value of the mixture out of proportion to the amount added".

A paper by Hove and Harrell in Cereal Chemistry, Vol. 20, makes this concluding statement. "It is concluded that wheat germ can be used in the human dietary as a supplementary protein, equal in value to casein or other animal proteins."

Now, as to corn germ, I quote Dr. H. H. Mitchell, an outstanding authority on proteins. He compares defatted corn germ with beef round. In a letter to the National Research Council reviewing his experiments he says, "It is evident from these data that the protein (nitrogen) of defatted corn germ is 85 per cent as digestible as the protein of beef round, but that its biological value for the growing rat is as high as that of beef round."

And keep in mind that this same corn embryo is one of the richest foods known in B-1, phosphorus and iron.

At the University of Chicago, where they are studying proteins by regenerating plasma protein in animals and measuring the formation of antibodies in the blood as a basis of determining biologic value of proteins, they are examining our defatted wheat germ and corn germ. I am permitted to report that preliminary experiments show that defatted corn germ and defatted wheat germ have been revealed by this laboratory to be excellent sources of high quality protein. It is this same laboratory that has revealed the significance of protein in preventing sickness and death from pestilence after the war. Dr. A. J. Carlson and Dr.

Paul Cannon believe that the toll from infectious diseases after starvation is due in a large part to the lack of high quality protein.

If you took a poll of nutritionists, they will agree that the need for sufficient high quality protein is just as great as the need for the B vitamins. They will say that cereals should provide much of this protein, but it is not clear whether they mean whole wheat and whole corn, or degerminated wheat and degerminated corn. Recently several Governmental spokesmen made speeches about the public eating the grain directly for efficiency, instead of feeding it to hogs. The only trouble is that these spokesmen forgot to find out that the public eats degerminated corn and the hogs eat nutritious whole corn. This makes the suggestion of getting greater efficiency by ourselves eating the corn a little "lopsided", to say the least. Let us be clear on this question. We eat most of our cereals as degerminated wheat and corn. Degerminated wheat and corn contain poor quality protein. Clinics are now evaluating the critical significance of this deficiency in our diet. The results are already sufficient to say that the loss of the high quality protein of our cereal germs is at least as serious to our national nutrition as the loss of the thiamin, riboflavin and niacin of the germ.

It is no accident that the so called infant cereals contain extra wheat embryo; 4, 7, 10 and 15% are the quantities taken from labels of cereals on the market. Research after research have been reported to reveal that babies thrive on these wheat germ cereals. Pediatricians have learned to appreciate the wheat germ in these infant cereals for the known vitamins, the "powerful unknowns", the high quality protein and valuable minerals wheat germ contains.

Let us consider the important experiment of an accepted authority on proteins, Dr. D. Breese Jones of the Protein and Nutrition Research Division of the United States Department of Agriculture. He states, "No matter how many vitamins or how many mineral elements may be supplied

in the diet, satisfactory growth will not result if any one of the ten nutritionally, essential amino acids be lacking. Wide publicity is being given to so called "enriched" flour as a great development in improving the nutritive value of wheat flour. The results of our experiments show that, even after the enrichment with eight vitamins and twelve mineral elements, the growth promoting value of white flour can be still increased two-fold by protein supplementation with 10 parts of peanut or cotton seed flour, and four-fold with soybean flour".

Now, if we consider the unpublished research by Dr. H. H. Mitchell and others revealing that the protein from corn germ and wheat germ is superior to soybean flour, the significance of the limitations of "enrichment" to adequately replace the wheat and corn germ largely discarded from our cereal foods is apparent.

Supply of Wheat Embryo

An unfounded impression exists that there is not enough wheat germ to bother with. We who know the facts about our own business, however, are aware that we could contract for seventy five million pounds a year of high quality wheat germ in the United States and Canada. From this we could make sixty five million pounds of a defatted wheat germ, a perfectly stable 40% protein food. Is that worth saving? Right now we ourselves process close to three million pounds, obtained from just TWO flour mills, and this is just half of their production. We have been wondering where the Japanese get their wheat germ. The Japanese seem to consider wheat germ important enough. According to the Board of Economic Warfare, wheat germ tablets are part of the field ration of the Japanese soldier.

The present uses of our defatted wheat germ are in baby cereals, baby soups, bread, macaroni products, adult cereals, dry mixture drinks (malted Milk-sugar mixes) meat substitutes, peanut butter, packaged wheat germ—pharmaceutical trade, and grocery trade—incorporation in various

pharmaceutical products. I amphasize that this is now being done. We sell our product for these purposes and have been doing it for years. And, of course, a large number of new uses are being tested. An ingredient of dehydrated soups; an ingredient of sausage and other meat products for lend-lease meats, are examples.

I estimated that we could have more than 65 million pounds of defatted wheat germ a year. A pound of defatted wheat germ represents 15 daily portions of 30 grams each, which will provide the total B-1 requirement, a substantial part of other B vitamin requirements, one sixth the total protein requirement, one third the iron requirement, two fifths the phosphorus requirement of a child for one day.

Thus we have about one billion daily portions, or a yearly supply for more than 2½ million children . . . a perfectly stable food concentrate that Nature has produced in the embryo of wheat—a product that can be stored indefinitely, that could be manufactured *now*, for *use after the war*, to aid in prevention of the famine and pestilence that awaits many of the world's children.

Supply of Corn Germ

In corn germ we have a product that is only one year old as a human food. It is now being used for the first time in food products and there are 750 million pounds of it available every year. I repeat, 750 million pounds a year . . . of food of the highest order in nutrition value, in palatability, in its adaptability as an ingredient of foods.

Considering uses for corn germ, all that has been done with defatted wheat germ can be done with defatted corn germ. One packing plant is now using this product as a filler and protein supplement for meat products. Tests are being carried out by large processors with the use of this product in an adult cereal. The use of corn germ as a supplement to all types of flour and cereal products is obvious. Here are the figures:

Available corn germ	750,000,000 pounds
Corn oil	200,000,000 pounds
Defatted germ (corn oil removed, and shrinkage)	500,000,000 pounds

Because of the lower protein content of corn germ as compared with wheat germ, let us assume that two ounces of corn germ per child per day, will be made available. This means twice the daily requirement of B-1, a substantial part of the rest of the B complex requirements, one sixth the protein requirement, and complete iron and phosphorus requirement, a daily supply for 15 million children for one year. (A more accurate figure would be twice this number.) And the 200,000,000 pounds of corn oil annually deserves more than a mention; but there is no time here to expand on that theme.

Is It Practical?

It is not surprising that the question should be asked, "Is it practical?" Let me ask, is the discovery of new food—not requiring the raising of new crops—a food, stable, palatable, available in hundreds of millions of pounds per year from corn already grown and processed—is this as practical and significant a development, as new oil wells, or new metal or coal mines or any new wealth? Of course it is. Is the discovery of something that will add 15 cents of value to every bushel of corn significant to the economy of our nation? Of course it is.

I am asked, "How would you add the germ to wheat meal, corn meal and other cereal foods?" Here is a simple practical idea. Just put a half ounce or ounce of the germ in a small sack in every pound package of degerminated cereal. It does not require mixing with the flour or the cereal. Let mother "see" the vitamins. Let her add the germ to the daily diet as she sees fit. She may not want it in cereal. She may want to use it in pancakes or soup or meat loaf. The important point is that the Federal Security Agency should tell her the truth—that she needs the germ of the grain and

should use it—just as it has told her she must use "enriched" bread and "enriched" wheat cereal.

Practical? Let it be emphasized in recapitulation that there is now in operation a successful manufacturing plant, producing stabilized defatted cereal germs. These are palatable foods, ideally fit for child feeding. They contain protein in equal biologic quality, and equal percentage quantity, to the best form of animal protein. They contain more vitamin B-1 than is found in any other common food. They are excellent sources of the B complex considered as a whole. They contain more iron and phosphorus than are found in any other common food.

The source material is wheat and corn embryo now diverted into animal feeds or destroyed in alcohol distilleries. Quantity available, processed, would provide a good part of the essential nutritional values for fifteen million children annually. No protein compares with it and I include yeast protein in that statement, considering digestibility as well as biologic availability and price.

No new acreage, no new crops required to obtain a great new source of food—a new source of wealth from America's great grain crops. When the corn farmers of this nation become aware of this great source of food I don't believe they will sit by and allow a large part of their grain be diverted into animal feeds, much of it destroyed, when it could be used as a human food equal to meat; they will object to this economic loss they take from this wasting of human food. I believe, too, that those agencies responsible for feeding our allies, will not allow the waste of hundreds of millions of pounds of high quality food as soon as they become aware of the facts.

Why the Lack of Official Interest?

You may wonder, as I do, what the "catch" is. The conservation of corn germ and wheat germ seems so reasonable. So simple! Is the raw material available? Yes. Will it

take any new machinery to make that raw material available? No. Is it now being done on a practical small scale? Yes. All it needs is enlargement of present facilities with no more critical materials than it would take to put up a soybean plant. Then why, you ask, if no disagreement exists as to the vital nature of wheat and corn germ, has there not been more vigorous action toward saving it? Why have we not become interested in conserving a vital food which is just as critical as aluminum, steel, oil? Why have we not developed a plan to save the wheat and corn germ; to put up a stock pile of food recognized as the only food available in large quantities that is equal to meat and can be utilized by infants and small children? Why have we not fostered such a plan before the food shortage had reached a critical stage?

It may be that our enthusiasm for pure vitamins has blinded us a little to the vital nature of high quality protein and the natural B complex. It may be partly that many of us have not realized that wheat and corn germ have actually been stabilized. And it may be the tragic circumstances which so often allow many years to pass before a new discovery is put to work for mankind. To speed this development, I have asked the authorities in Washington to take over the entire project. We give it to them unconditionally, to the Secretary of Agriculture and to the Federal Security Agency. We say it as we have said many times, "This development belongs to the nation."

Our Purpose in Revealing the Facts

If we were not at war, I would not be here. In free America, individuals through free enterprise and faith, create and build their ideas into realities. We would do it ourselves. We would go directly to the processors of food and the people who buy food. We would tell them the facts. But, we are at war, and all agree that this is an indispensable contribution to our country's food needs and the food needs of our allies now and after the war. No one dare be detached

about the discovery of a great new source of food at this time in world affairs.

The farmer who grows wheat and corn, the farm organizations who represent them and the agricultural colleges who know the nutritional values of wheat and corn germ, surely will see the significance of conserving hundreds of millions of pounds of valuable food—this food that represents millions of dollars of new wealth to the American farmer, and represents life itself, to the world's millions of starving children; when they realize that vitamin enrichment is no substitute for the embryo itself and that our people suffer an economic loss as well as nutritional loss in not utilizing the whole embryo of which the vitamins are only a small part.

I cannot believe that this nation as a whole will accept a pittance of pure vitamins as an answer to our critical food problem when vitamins and protein in abundance are ours for the taking, in the embryos of cereals.

CHAPTER XX

Vitamins from Grass and Alfalfa

By W. A. HARDING
Evergreen Farms, Raymondville, Texas
In Rio Grande Valley

Chemurgic Papers, 1945 Series, No. 1

In pondering over the subject, "Vitamins from Grass and Alfalfa", I tried to think back to my first recollectable contact with vitamins. Did you know that the actual discoveries and segregation of our best known vitamins were made as recently as the early 1930's? Yet my earliest recollection of contact or knowledge of what is now called vitamins runs back 60 years. When I was at the age of 9, a graying old uncle of mine early one Spring day came over to our home and asked my mother if "Willie could come out to his farm and herd the sheep around the fields" where they could get the early sprouting grasses, and then to my non-understanding child mind added this enigmatic sentence: "It would be of great benefit to the ewes in dropping their lambs two or three weeks later." A fact known to every raiser of livestock for thousands of years, "Breed animals as much as possible to deliver their young while on succulent pastures.

Five years after the above incident I began a six year preparatory and college course, working for my board and room on the small farm of an old eccentric bachelor, presided over by an older, unmarried sister. It seems that this man had been given up to die years before of several ailments, some of them little known of at that time by the medical fraternity. He was a stubborn man and determined to take his own case in hand. He adopted a slogan, "Eat right; live right, do right," and proceeded to acquire knowledge along those lines by the purchase of a whole library

of books touching these subjects. When I entered that home it was on a strict, regular diet—breakfast, a heaping bowl of rolled oats with sugar and plenty of real, rich cream, toasted graham bread spread generously with butter, bacon and eggs, as many as you wanted. Dinner—boiled or roasted meat of some kind, potatoes boiled with their jackets on, other garden vegetables and small fruits in season—no pastry. Supper—a bowl of whole wheat porridge with sugar and ample cream, usually applesauce, either fresh from the orchard or from the cellar's gallons and gallons canned for all around year's use, always with the apple skin left on and the core in. The whole wheat porridge was the novelty. It was really whole wheat, for the fine, plump wheat kernels were ground in a large size family coffee mill. The beverage for the three meals was water, and all the fresh sweet milk you could drink.

Why have I told you this story? Because the old man had found the actual source of all the vitamins which the scientist and chemist did not segregate until forty years later, and his reward to live almost a hundred years, and be regarded as "a good old, eccentric fellow".

At the end of the six years preparatory and college course, and life in this family I had absorbed so much of its way of living that I wrote my valedictory address on the subject of "Whole Wheat Flour".

Grass, The Basis of Civilization

Life of civilized and savage people differ fundamentally because: 1. Savages spend the entire (or most) of their time in obtaining food and shelter on the day by day basis. 2. Civilized people spend only a small part of their energy in obtaining food.

As less time was required for the production of food, leisure time developed. This leisure time (based on efficient food production) led to the development of civilization. The

complexity of the use of this extra time (industrialization) is the basis of world politics and economics.

The development of civilization may not have been a good thing for the human race in some respects, for it brought many conditions which are responsible for most of the modern ailments of human beings.

Of all the plants in nature, only grass can yield basic food material on the grand scale over wide areas. Plants giving greater yields of food have a too limited geographical range to support great civilizations.

Grass, first used in natural state, and nomadic civilizations were based on the animals which followed the grass; for example, the American Indian. If grass is cultivated by man, the productivity so increases that nomadic civilizations become unnecessary, and the stable agriculture begins. Fundamental differences between the civilizations of the North American Indians and the Indians of Latin America depend on the fact that the North American Indians were nomads and followed the grass according to season and area, while the Latin American Indians cultivated grass in permanent locations.

All great civilizations are built around specific kinds of grass. Rice was the food supply of the oriental people. Corn was the food of the advanced Indian civilizations of Latin America (Aztecs, Incas). Wheat was the food of the original Europeans (probably spread from the Nile, Tigris and Euphrates valleys). All stable agricultural civilizations of the world depend, directly or indirectly, on grass.

Agricultural Classes of Grass

Cereal grasses are grasses which furnish edible seeds, such as wheat, barley, oats, rice, and corn. All of these but corn are often called "small cereals" since they differ so much from corn, but corn is a grass just as truly as wheat.

Forage grasses are grasses grown not for their seeds, but

for the leafy part of the plant. Forage grasses are indirect sources of food by being the food of animals.

Most of the grasses cultivated by man are grown for the seed. Hence the vast amount of plant breeding, creation of new varieties, field tests, introduction tests, cultural tests have been directed toward increasing the yield of the grain.

Grasses grown for forage have received but a small fraction of the agricultural study that has been expended on grasses. Forage grasses have been left very much as they were. They were used more or less in their native state. If one wanted more forage for stock, he merely obtained more land. In early days in the United States, the motto was "the more land, the more cattle." That day is now past, for more and more land cannot be obtained. The scientists of the United States are now intensively studying how to grow better forage grasses. Laboratories at the University of Illinois, University of Pennsylvania, Purdue University, and Cornell University are making contributions to this field.

Food Value of Grass Leaves

By forage grass, we mean grasses grown for the food value of their leaves. It has been recently discovered that the "small cereals" possess leaf of extraordinary value. In the young stages the leaves of wheat, rye, oats and barley are exceptionally rich in vitamins. They are especially rich in the water soluble vitamins. This is very important since the animal body cannot store up large reserves of the vitamins of this group, since they are soluble in water and are excreted in perspiration and in the urine.

Examples of water soluble vitamins which are especially concentrated in young cereal leaves are vitamin C, vitamin B-1 and vitamin B-2. High concentrations of protein also occur in these young leaves; for example, up to 40 per cent of the dry weight may be digestible protein. Protein concentrations of 20 to 25 per cent are very common. Mineral salts are also among the foods which accumulate in young

grass leaves. Frequently 10 to 20 per cent of the dry weight is composed of mineral salts.

The "discovery of grass" was made only ten years ago—by Charles F. Schnabel—a poor, struggling unknown Kansas City chemist, who for six months fed the tender green unjointed blades of oat grasses to 100 hens. He collected more than 90 eggs every day for half-a-year. Schnabel's whole family ate grass, eight of them. Only a dollar a day was spent for other food for three years. All enjoyed excellent health, health so good that not a single one of the children, whose combined ages now total 90 years, has a decayed tooth, while 90 per cent of all school children have one or more decayed teeth.

This amazing grass is the richest of all natural foods in those vitamins and minerals necessary for perfect health. Dried, young, green grasses, ground into powder, bring the nutritious goodness of luscious Spring grass at all times of the year, for yourself, for your livestock and poultry. This is not just any grass, it is Cerogras. The tender blades of oats, wheat, barley, rye and sudan grasses that have been scientifically grown, cut, blended and tested to yield a maximum of life-giving nutrients.

Unjointed Grasses

One of Nature's great mysteries has at last been solved, the secret of health. The same secret that most animals have known for millions of years has at last given way to man's incessant curiosity to provide him with the best and most abundant of all foods.

These unjointed cereal grasses, like the common bamboo fishing pole, when mature, have a number of nodes or joints in their stalks. Each joint or node represents a stage of growth closer to maturity. The older the plant, the greater the number of joints.

Before the first joint is formed the plant is tender, green, succulent. During this period, which lasts about eighteen

days, when conditions are normal, these grasses increase in vitamin, mineral and protein content. The whole young plant is striving, working, exerting itself to store up the energy it will need to joint and reproduce.

The peak of this stored-up energy comes at the time the first joint is formed. After the first joint appears the plant becomes fibrous and woody. More and more fiber replaces the good food elements until only the straw and grain remain. Only for a few hours near the time of the first jointing is grass at its very peak in healthful, life-giving nutrients. This was Schnabel's discovery. This is the secret of harvesting grasses for human and animal food.

There are indications that Cerogras also contains hormone-like factors which improve the general health of poultry, stimulate egg production, and increase hatchability. A silver fox farm where the females normally whelped four young per head increased their offspring to six on their regular diet supplemented with a ration of Cerogras the year around. These hormone-like factors along with recently discovered "folic acid" and "the grass juice factor" may explain the fundamental value of grass.

It is obvious that the leaves of cereals and other grasses are ostensibly rich in the food substances needed by animals.

Commercial Grass Dehydration

The food value of young grass leaves is so great that many tons of young grass is now especially grown on rich soils, harvested just before jointing, and dehydrated. The Cerophyll Laboratory of Kansas City marketed 15,000,000 pounds of specially prepared dehydrated cereal grass leaves during 1943, and their production during 1944 is considerably larger.

I shall describe here the grass program of Evergreen Farms, and devote more space to what is now known as Cerogras, for it is new and novel in comparison with alfalfa, although Evergreen Farms produce a larger volume

of alfalfa because its yield is greater per acre, and needed in great tonnage to increase high protein feed for animals for the duration of the war.

Only the best alfalfa seed obtainable is sown on Evergreen Farms, and we follow very closely the results of many experimental and breeding tests being carried out on oats, barley, wheat, rye and sudan at the agricultural stations for increasing leaf growth, resistance to rust and pests, and higher gathering protein content. Years of research have proven that just not any land is suitable for growing the best grasses. *Certain minerals must be present.* In the last two years one man has traveled a hundred thousand miles to find only two per cent of America's soil good enough to grow Cerogras. You may appreciate this statement better when you consider our great grain growing sections have run down the fertility of soil, raising grain only, which contains only 11 to 15 per cent of protein in the mature grain, and this year the set standards for protein in flour had to be lowered because the protein content of our wheat crop over large areas was one to two per cent below heretofore normal average. The requirement of Cerogras is that the producer or processor deliver a product which will average a protein content during the year of 20 per cent. Evergreen Farms began its operations five years ago and during the first two years over ten thousand separate laboratory tests were made, seeking the presence of, and how much there might be, of over twenty different minerals in several hundred soil samples taken from all the forty acre tracts on Evergreen Farms' eighteen hundred acres.

Rain seldom comes at the right time and in the right quantity for any farmer anywhere. So Evergreen Farms quickly gave up any hope of getting natural rainfall to nourish a crop of alfalfa which we cut every four weeks, or a cereal grass crop which should be cut every eighteen days, if we expect to reap maximum production and highest protein content. That means watering right after every cutting and a quick flash, luxuriant growth chock full of the "stuff"

that makes a cow give milk; a hen lay eggs; a pig make pork and a lamb grow lamb chops, to say nothing of the running colt winning the race.

So we turned early to irrigation under the Willacy County Irrigation System, completed during our first year of operation. Flood irrigation with border controls was not practical for frequent irrigation and the kind of harvesters used in cutting and elevating green crops into trailer-trucks, so we began the installation of rain sprinkler pressure systems and today we have four, each one throwing 1200 to 1500 gallons per minute. When all four are in operation we can thoroughly sprinkle every square foot of eighty acres with two and one-half inches of rain in twenty-four hours. The very best growing conditions for young oats, wheat, barley, rye, sudan and alfalfa are thus provided.

Formerly harvesting was a difficult problem. Today it is solved by using an ingenious mowing machine. This machine, cutting two acres per hour, picks the grass up in a scoop-like plate as it falls before the mower. The luscious green grass is tossed into a trailer-truck, which rushes it to the dehydrator.

At the dehydrator these unjointed grasses are pitched into a cutter, then onto a moving belt which tumbles them into a huge hot drum. At an initial temperature of 1600 degrees three tons of water can be removed in one hour. Every forkfull goes through this drying process in two minutes. Thus flash drying has captured the vitamin potency of unjointed grasses at their height.

All grasses from the various fields are not exactly the same in protein and vitamin analysis. For that reason laboratory tests are run to determine how the different grasses should be mixed to make a uniform product. Thus only vitamin—and protein—guaranteed grasses leave the blender.

Hundred pound sacks of freshly blended grasses are then rushed to giant refrigerators, where temperatures ap-

proaching zero hold the vitamin content intact. The fresh, tender unjointed grasses of the open field have thus been captivated in their original form and converted into Cerogras.

Alfalfa goes through the same process. Our slogan is "Fresh from the field to the user or feed mixer within twenty-four hours the year around." Contracts for our entire production of both alfalfa and Cerogras are made for a whole year in advance. I believe that Evergreen Farms was the first farm crop producer in the Rio Grande Valley to contract its entire possible production a whole year in advance at a set price. The security it gave was so satisfying we have maintained the practice ever since. Our first contract in 1940 was for a minimum of a thousand tons and our contracts for 1945 are for seven thousand five hundred tons and more if we can produce it. We started with one dehydration unit and will have our third one ready to push out the 1945 crop. Tonnage production per acre on Evergreen Farms averages a ton to a ton and a half of dehydrated Cerogras on each planting of cereals, with two plantings a year and a cover crop of cowpeas or sesbania to keep up fertility of the soil.

On alfalfa we aim to average five tons of dehydrated meal per acre per year cutting eight or ten times averaging eighteen cuttings in two years, which is about the efficient life of alfalfa under our high pressure growing system. We have learned a lot of things about Cerogras and alfalfa in five years, and solved a lot of problems, but others still keep bobbing up. I could elaborate on soil preparation—deep plowing, 16 to 20 inches deep, land levelling with a landplane that takes all the power of a 75 HP Caterpillar tractor, and the effect of fertilizer on Cerogras, and the story of alfalfa gathering nitrogen and turning it back in protein at a fabulous rate in comparison with any other marketable commercial crop, but that will have to wait for some future time.

What Becomes of Dehydrated Grass?

Most of the enormous amount of this dehydrated grass is finely ground and mixed with many kinds of animal foods. The value of the grass as a component of these foods depends on its vitamin, protein and mineral content. Chickens, silver foxes and race horses are among the most important animals fed with these preparations. In view of what has been said about the food value of grass, why can it not be used as a human food?

First, let us glance for a moment at the essential elements, namely, what are now called "the necessary vitamins for healthful living". Out of all the vitamins known today by modern science only seven have so far been proven absolutely essential to the human diet. A, B-1, B-2, C, D, Niacin and K. The minimum daily requirement has been established for only five of these, A, B-1, B-2, C and D. An eminent nutritional authority has said: "Additional vitamins beyond those already known, may be discovered as indispensable to human nutrition." This means that certain unknown vitamins may be found necessary to man.

The unjointed grasses of 18-day old Cerogras, containing more vitamins than any other known food, are a veritable storehouse of all these natural vitamins: Carotene (Provitamin A); Vitamins B-1, B-2, (or G), C, E, G, K; Pantothenic Acid; Nicotinic Acid; Grass juice factor; Anti-Gizzard erosion factor; Chlorophyll and Xanthophyll (non-vitamin factors); Factors U, R, S; Biotin; Inositol; Choline; and Folic acid.

Every known vitamin with the exception of vitamin D, the sunshine vitamin, has been found in grass. Many unknown factors which will undoubtedly play an important role in the vitamin field of the future will yet be found and isolated from this richest of all plant foods.

It is now time for the next question, "How do the vitamins in Cerogras compare with the vitamins in our present

best known recommended vitamin foods?" Well, here is the answer in a summary of tests made by schools of agriculture, universities, colleges, hospitals, doctors and scientists over their test tubes, pipets, flaks and hot flames:

Grass contained three times as many calories and twice as much protein, per pound, as the next best common source, eggs. In the vitamin columns grass did even better. Grass contained twenty times more vitamin A than egg, and thirty times more than the same amount of other green vegetables. Vitamin B was seven times more abundant in cereal grass than in eggs. Oranges and tomato juice contained only one-eighth as much vitamin C as did an equal weight of dry grass.

Vitamin G was ten times more plentiful in dried cereal grasses than in eggs and twenty times more potent than milk—pound for pound. In the bone building minerals, calcium and phosphorus, young grass had twice the potency of milk and eggs. And in the blood building iron, grass was twenty to sixty times richer than eggs or leafy green vegetables.

Strange as it may seem, thousands of tons of this grass have been especially cleaned, compacted into small pellets and sold for human food. The choicest and most carefully processed of all Cerogras is now available as a human food supplement, being marketed under the trade name Cerophyl. Available in palatable powder or tablet form, 12 to 15 pounds of Cerophyl supplies more vitamins and minerals than the average 340 pounds of citrus fruits and green vegetables eaten by the average person each year.

Cerophyl bears the Seal of Acceptance of the American Medical Association's Council on Foods. Sealed under inert gas, its freshness and food value are preserved for long periods of time. Taken on the prescription of your physician, Cerophyl may bring you better health, more energy and keener vision. Most of the large specialized food stores of the United States sell Cerophyl and Viet as a human food.

These commercial preparations of grass leaves now furnish one of the largest sources in the United States of vitamins for human beings.

But who would actually eat grass? The answer is simple, the taste for it is easily acquired, children learn to relish it as quickly as any other food except milk. Undoubtedly, in the future, grass leaves will become one of the important direct sources of human foods.

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Are We Starving to Death?

From The Saturday Evening Post
NEIL M. CLARK
September 1, 1945

We have drawn on the mineral bank more than we have paid in, and bankruptcy is coming fast. Diseases are beginning to multiply. Heart ailments that can be traced to diet are going up alarmingly. Diabetes, arthritis, cancer, anemia, dental caries and many of the more obscure ailments have struck with increasing severity. Millions of us try to supply what we vaguely feel is wanting, by buying pills at the drugstore. Even if we aren't sick enough to see a doctor, we may be only half-well. A study in a California aircraft plant showed a correlation between fatigue, work spoilage, reduced output and absenteeism, and shortages of vitamins A and C in workers' diets. Medical progress has been wonderful, but one of the more significant medical discoveries is the fact that almost any disease can be produced experimentally by faulty food. Today, doctors in increasing numbers are the ones who are saying that the tide is getting too strong for cure alone. There must be prevention. And prevention starts in the soil.

The process of decay has gone faster and further in some parts of the country than others. Albrecht cites the fact that the South has a heavy rainfall and a lot of leaching and cropping to reduce soil minerals rapidly. The South, consequently, is the part of the country where farmers use the most fertilizer; they have to. But even so, input in most places has fallen behind outgo, and Albrecht says it's a direct result of that that makes so serious the Rountree report that in one Southern state no less than 70 of 100 potential inductees for military service in this war were rejected on physical grounds, whereas in Colorado, where mineral depletion has

been less, 70 out of 100 were accepted. Those Southerners simply were not eating well enough.

The problem, Albrecht says, is rapidly reaching the size of a catastrophe, and if carried much further, could mean national suicide. Some future Gibbon, he says, might sit down to write The Decline and Fall of the American Republic. Soil health is that important. It could happen here.

Can the tragedy be prevented? If so, how? Not all the steps are known yet, Albrecht says, but the direction we must travel is absolutely clear. We must restore our soil bank account. Our soils, like ourselves, must be fed back to health. That's a tremendous subject. No two soils have exactly the same history, topography and climate, and soil-mineral differences may occur within the same fence lines. Albrecht visited a famous Hereford farm in Missouri and found an entire beef herd seriously afflicted with diseases that doctoring seemed unable to cure. On another farm near by he found a similar herd in practically perfect health. Oddly, the herd on the second farm was started by animals born and brought up on the first farm. The health difference was a soil difference. The first man had been operating for fifty years on the same farm and had not maintained soil minerals. The second number of sick people fed at his farm have achieved near-miraculous cures. Citrus groves in Florida are planted on sand under fifty annual inches of rain, and to furnish the trees the copper and zinc they can't find in the soil, they are spoon-fed—the minerals are sprayed on and the trees take them in through their leaves. The iron content of milk has been increased from twenty-one to fifty-five parts per million by proper feeding of soils grazed by the cows. But Albrecht warns that there are no soil cure-alls. "The soil factory," he pionts out, "runs by processes more subtle than anything in a man-built factory. Much remains to be known. Lime is generally good on soils, but it's possible to lime too much. Boron helps to make oranges, but an overdose can make them sick." All these things are to be explored. But Dr. Jonathan Forman, editor of the Ohio State

Medical Journal and a serious student of soils and nutrition, says confidently that there is no reason why the average man, if "well-bred and well-fed," should not live to be a hundred and enjoy good health.

The city man is perhaps more deeply concerned in all this than the country man, for he is not a producer of his own food and must depend absolutely on others for the mineral richness of what he eats. So the city must learn to be tolerant of new steps that farmers must take, and of the possible consequences of those steps to the city man's pocketbook. Hitherto, Albrecht says, the farmer, thanks to the system of food distribution, has often been forced to mine his soil. "Hardly any farmer," he says, "wilfully destroys soil fertility. But he has been forced. The grocer says, 'I can pay only so much.' He passes that buck to the wholesaler, the wholesaler passes it to the commission man, the commission man passes it to the farmer, and the farmer passes it to the land. There's no other place. He proceeds to use his soil like a private gold mine, not as a property affected with an enduring public interest. We must enable farmers to keep on using their soil to produce food, and at the same time maintain mineral-rich fertility."

Our war-expanded chemical industry, Albrecht thinks, will find its greatest peacetime opportunity in making soil-restoring products that will help to restore our national health.

Remarkable work has already been done in treating sick soils. After adding a pinch of manganese in certain fields, a food processor harvested tomatoes with triple the vitamin C content. A little boron around apple trees in the Northwest apparently has doubled the vitamin A content of the fruit. A retiring genius named Albert Carter Savage has been experimenting for years in Kentucky with mineralized vegetables.

I heard this absorbing story about health in America from Dr. William A. Albrecht of the University of Missouri,

pioneer and leader in soil chemistry and nutritional research. "Nutritional research got under way about the turn of the century," Albrecht said. "Doctors, through experiment and observation, began to understand that many diseases could be traced to dietary deficiencies, and that many sick people were hungry people. They called it 'hidden hunger' because people might eat three square meals a day and still suffer from it. One of the hidden hungers was for calcium, a shortage of which could cause rickets. Goiter was hooked up with a shortage of iodine; night blindness with a shortage of carotene; anemia with iron, and possibly copper, shortage; thyroid troubles with a shortage of zinc; tonsillitis with a deficiency of silver; tooth decay with shortages of calcium, phosphorus, fluorine.

"Now, plants are the earth's basic food factory and nourishment warehouse," Albrecht continued. "We eat them or we eat animals grown by eating them. If something is missing from our food that we need for health, it must be missing or deficient in plants. Why is it missing?"

Dr. Albrecht made the tie-up between human health and the soil the major goal of his research. Through a series of experiments he developed a complete hypothesis as to what goes on in soils, how plants and soils work together, and how soils become sick and make plants, and then men and women, sick.

A plant, he points out, obtains only a small part of its total growth from soil materials; the rest comes from air, water and sunshine.

"What the soil contributes to growing plants," Albrecht says, "is very little in amount, compared with what air, water and sunshine provide; on the average, it amounts to about five parts in one hundred. But that little is absolutely essential to plant and human health. For soil materials are 'grow' foods—the minerals that make bones and teeth in animals, and keep us provided with a strong structure, without which we're like an automobile built of soft tin. Air,

water and sunshine, on the other hand, make the 'go' foods —fuel and energy to keep the machine running. There's no indication we'll ever run short of the airborne elements in our foods. But right now we're running short of soil-borne elements. And that's our trouble. When we're short of minerals, we're short of basic health. Short of vitamins, too, for there's some unknown connection between minerals and vitamins. We know when minerals in a soil are abundant, vitamins usually are abundant in the plants that grow there."

As the Soil, So the Man

Florida Times-Union, Jacksonville, Florida

Experiments in farming and gardening that have been under way for sometime in Hancock County, Georgia, are bringing results of great importance to the South's social structure. They are proving that man's health, physical stamina and outlook on life conform to the soils in which he grows his crops.

The discoveries are, in a measure, accidental. They are described in an article written by Eugene Anderson for the Macon Telegraph, who tells about Dr. I. H. Moore going into the middle section of Georgia on scientific research, seeking to learn why kidney stones were more often reported from that section than from elsewhere.

He didn't learn, because he couldn't locate the cause of such stones, but he did learn that water is not the secret. Something else or the lack of something else is the cause. Of course, if water does not control the kidney stone problem, food might do so, and Dr. Moore decided that phase of the problem was worth investigating.

Dr. T. F. Abercrombie, medical director of the State Health Department, had been saying for many years that the Nation should become interested in producing food values instead of big yields. He believed the vitamin and mineral content of food controls nutritive value. He and Dr. Moore agreed, and 16 test gardens in Hancock County were started by farmers directed by the health department.

Samples of the different products in these gardens are sent to the State's experiment station at Griffin, to be analyzed. From the analysis the needs of the soil are discovered, and those needs are supplied to the land through fertilizer and mineral applications, such as lime, phosphorus,

acids and legumes. "As the soil is, so will the man be. If the soil is sick and weak, so will the products be sick and weak, and so will be the animals and humans who eat the products." That's the fundamental idea, Mr. Anderson writes, and "blood analysis may yet show what is lacking in man or animal. Many claim it is done now. It's leading to a revolution in agriculture and horticulture."

The canning plant manager at Sparta, the writer adds, says he could sell 20,000 quarts of vegetables canned from the experimental gardens, and he wouldn't have to send a can away from the town of Sparta. People want the products of the health gardens, and when the growers of "poor food" in poor gardens see the difference in their health and that of their neighbors and in the profits from "health gardens" as compared with the lack of profits from the "ordinary or poor gardens," the "health gardens" will take the place of all the others.

As to the health results, a dwarf who had not grown in two years added an inch on health garden products and proper vitamins in a few months, says Dr. Moore, who believes that the discoveries promise to be as sensational in the food and health problems as was the discovery of vitamins and insulin. He quotes other scientists who believe the same thing.

Cornell University sent men down to study the work and has constructed a $100,000 laboratory and employed several $10,000 a year men to pursue the idea.

Continuing, the story adds: "George White (the name is fictitious but the man is painfully real) is typical of the farmers who get about as if they had hookworm or pellagra. He has 10 children, three of whom are under three years old. The health nurse and the doctor have been trying to keep all of them alive, but it's been a hard job. White sold his cow because of hard times and he wouldn't fool with chickens and pigs. He didn't plant a garden because his one crop, cotton, took so much time.

" 'George is a good fellow and comes from good stock," Dr. Moore said. "But he has no energy and no power of self-direction because he is undernourished. The lack of phosphorus in his food kills his energy and intellect. Go by his place most any time of the day and you'll see him sitting about, doing nothing and thinking nothing.'

"Families in comparable circumstances who have been eating from health gardens make a prettier picture. The farmer is energetic, his children rosy-faced. He does well on the farm and they are learning in school. They really are living.

"If science has its way, gray hair may become its natural color, dull and bedimmed eyes may become brilliant and powerful, headache and backache powders will no longer be needed; stunted growth, infantile paralysis, the fevers and nearly all of the diseases that have cursed man's existence will disappear, and longevity can be relied upon. Food of a quality not often obtainable now will convert the druggist into a grocer and man will become healthy, strong and vigorous."

A thing to be remembered about the conditions herein discussed is that no matter how much food a person eats it will not keep him well and happy if it is lacking in minerals and vitamins. "Feed a man four or five times a day on food of the wrong quality," Dr. Moore stresses, "and he will become weak in mind, body and spirit and disease may overtake him."

May the director of man's destinies surround these experiments with His protective blessings, and speed their spreading over the vast areas where such benefits are so sorely needed.

Research Project Started by Dr. Ouida A. Abbott Grows

Florida Times-Union, Jacksonville, Florida
January 18, 1945

Dr. Ouida A. Abbott, home economics research scientist on the staff of the University of Florida, may not have been the first to become interested in the theory that nutritional deficiencies may be traced to the soils in which food crops grow, but she began studies in 1938 from which a movement is spreading that promises a revolution in food crop production and diet in America.

A lengthy article published in the St. Louis Post-Dispatch of Sunday, January 14, is based largely upon the discovery made by Dr. Abbott and the Florida Experiment Station. It is pointed out that five years ago, at the initiative of Henry A. Wallace, then Secretary of Agriculture, and Dr. C. E. Auchter, now Administrator of Agricultural Research, investigation was begun of the relationship between healthy soils, on the one hand, healthy plants and healthy domestic animals on the other—and the opposite, too, of course.

This project has its headquarters in the new plant, soil and nutrition laboratory at Cornell University and is directed by Dr. L. A. Maynard, nutritionist of international reputation, and virtually every agricultural experiment station in the United States is busy on some phase of it, as are 20 or more university and commercial laboratories.

Dr. Abbott began her studies after she had noted that malnutrition was most acute among inhabitants of a Florida county where the soil was composed chiefly of gray and white sand, and where the cattle suffered from a local ailment known as "salt sickness." In this area from 52 to 96 per cent of the children were anemic, while in other districts,

where the cattle were healthy, less than 23 per cent of the children were anemic.

The anemic children that were suffering from hookworm were cured of that ailment but still their blood count didn't go up, although without removing the parasites, it was possible to restore their blood count to normal simply by giving them iron.

Already the Florida Experiment Station had discovered that deficient soil and deficient forage caused the salt-sickness of the cattle. That being true, how about the children? They ate their turnip greens. Analysis revealed that the greens contained only about a fifth as much iron as turnip greens grown outside the district, on healthy soil.

This prompted the Experiment Station to try another experiment. It planted the same kind of turnip seed in four different Florida soils—and harvested four different grades of turnip greens, differing sharply in leaf form, succulence, and mineral content.

"It appears, then," Dr. Abbott wrote in summing up her findings, "that soil deficiency operating through the plants grown thereon, and ultimately in the health of the people, is a factor that should be considered in any section where nutritional anemia is endemic."

It is from this angle that the scientists are working now toward the establishment of a well balanced diet of natural foods grown on fertile soils, rich in essential minerals which are listed as: carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper and zinc. Seven undesirable minerals are: Selenium, thallium, fluorine, chromium, lead and arsenic.